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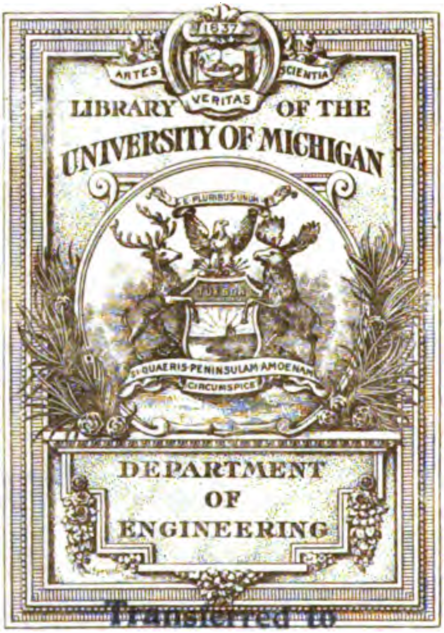

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American association for highway improvement

GOOD ROADS YEAR BOOK

1917

SIXTH ANNUAL EDITION

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PREFACE

Once again the American Highway Association calls the attention of all interested to the fact that in the United States today the problem of improved highways is not so much a problem of providing funds, but of intelligent and economical use of the funds which are available.

The public interest in road improvements during the last two years has been steadily growing; but it has been largely exhibited in a willingness to vote road bonds and to assume road taxes. The use of the funds so made available has apparently not yet given the American public any sustained concern. The reason is not far to seek. It lies in the assumption that highway construction and maintenance require little more than good faith and common sense. Many persons without engineering experience have been persuaded to acquiesce in methods of work which lead to unnecessary waste. Highway engineers throughout the country have been confronted with the necessity of directing the energies of enthusiastic advocates of better roads along lines at once financially and economically wise. Such educational work has been and still is no small task for men so busily engaged in the discharge of their usual duties as are the professional road-builders.

About a year ago, some of these engineers suggested that the American Highway Association could render valuable assistance by publishing in its Good Roads Year Book a detailed discussion of all of those simpler and untechnical features of highway construction and maintenance which a commissioner entrusted with the expenditure of road funds should know. The directors of the Association had previously authorized the preparation of a book of this character, for they realized that the excellent engineering treatises which have lately appeared are more useful to engineers than to commissioners and contractors. The preparation of such a reference book on road building, free from personal preferences and prejudices of individuals and applicable to the country as a whole, is impracticable except as a coöperative undertaking. This coöperation was volunteered by a number of engineers, and the Association accordingly undertook the work. Over fifty highway engineers throughout the country have furnished advice concerning the subjects to be treated and the character of the treatment, and valuable assistance in revising the chapters, all for the one purpose of giving to road officials who are not engineers the general information which these engineers are called upon to furnish. Part II of this volume is the result. Its usefulness and authoritative character are due to the engineers who have so contributed to it.

The American Highway Association publishes its GOOD ROADS YEAR BOOK annually as an important part of its work. Its purpose is to arouse an intelligent popular appreciation of highway improvements to the end that taxpayers may elect to their local highway boards men of proved business ability and will insist on placing the technical work under competent men. What is needed today is a larger return for the money now provided by taxes. The work will be better and more efficiently performed in proportion as the electors of a road district decide that this shall be the case.

The many changes in road laws made while this edition of the GOOD ROADS YEAR BOOK was in press make the pages of supplementary information at the end of the volume of particular importance, and the attention of the reader is specially called to them.

The American Highway Association is now sending each week to newspapers and agricultural journals a bulletin of news and short articles about road work. The bulletin is sent only to journals which have asked for it, and an indication that intelligent interest in rational road administration is growing is afforded by the fact that the combined circulation of the publications which now use this material aggregates the large total of nearly 9,000,000 copies per issue. The Association is also coöperating with educational institutions and state departments in spreading a knowledge of what good roads can accomplish for the districts they traverse. All who believe in getting a dollar's worth of good roads for every dollar invested in construction or maintenance of highways are again invited to join the Association and thus bear witness in an active and positive way to their coöperaton in a work of great economical and social value.

FAIRFAX HARRISON,
President.

Washington, March, 1917.

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PART I

Information Regarding Road Improvements under Federal, State, Territorial and Local Control

FEDERAL AID IN ROAD BUILDING[1]

The farmer has been, from time immemorial, paying the bill for the building and upkeep of public roads. Appropriations of State funds in recent years have transferred a slight portion of this burden to the owners of city property, but it is probably conservative to say that at least 75 per cent of the money raised for road purposes at the present time is paid by the owners of country property. According to the Census Report on Wealth, Debt, and Taxation, the total value of all real property and improvements in the United States in 1900 was $46,324,859,234, and of this amount farm lands and improvements constituted only $16,614,647,491, or a little more than one-third of the total real estate values in the United States. Since that time, on account of the very rapid growth of cities, it is probable that farm values are now less than one-third of the total real estate values. It is thus apparent that the owners of less than one-third of the real property are paying more than three-fourths of the cost of the public roads. This would be equitable if the public roads were of value only to the rural population, but, as the committee has pointed out in other portions of this report, the public road is of vital importance to the cities and is no longer of mere local significance. Inasmuch as the revenues of the federal government are derived from the dwellers of both city and country, the result of federal appropriations would be to tend in some measure to equalize the cost burdens as between city and country.

Legislation by congress requiring on the part of the States, as a condition to receiving federal aid, that they provide for systematic and responsible supervision of the joint funds thus created, would be a long step in the direction of effective road management now so urgently needed. It is a self-evident proposition that in small communities the selfish influence of powerful individuals has greater opportunity to act counter to the public welfare than in the larger political communities. Just as the county administration is less likely to be swayed by selfish interest than is the township, so is the State administration less subservient to the selfish interests of the few in the distribution of public improvements than is the county, but in both the county and the State political considerations constitute an ever-present menace or temptation, as the case may be, to sway the judgment of those in authority. The judgment of representatives of the federal government is not likely to be biased by local conditions, nor is the tenure of office of those who represent the federal government dependent upon the local electorate. It may, therefore, be reasonably expected that the federal representatives will stand for sound and impartial management of road funds and will give moral support to State officials, which will relieve those State officials of many embarrassments and burdens which they must now bear alone. Thus, first, by imposing a condition upon the States, and second, by providing an unbiased cooperative agency, the federal government would insure from the outset a management which would be reasonably free from criticism.

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[1] Extracts from Senate Report 250, 64th Congress, 1st Session; Report by Senator Bankhead for the Committee on Post Offices and Post Roads.

Any appropriation of money that does not carry with it a requirement for systematic and efficient road management would accomplish such trivial results as to scarcely affect the progress of road improvement in the United States. That this is easily capable of proof is indicated by the fact that the annual expenditures for road improvements in the United States are in excess of $300,000,000. If congress were to appropriate an amount as large as $25,000,000 annually and turn it over to existing agencies for expenditure, the net result would be to add $1 to every $12 now being expended. Such legislation would be "pork barrel" without a redeeming feature.

Federal legislation properly framed should insure the formation of a federal corps of highway engineers, representative of the best technical and practical ability obtainable in this country. The further requirement in suitably framed legislation that the States provide responsible and qualified agencies with which the federal government might cooperate would tend to bring about the retention, the improvement, or the establishment of highway departments in the respective States representative of the best ability in those States. Such a high standard on the part of the government and of the States must of necessity insure an excellence of methods and of results of the greatest benefit in the working out of the great task of providing adequate highways, throughout the United States. The influence and example of such thoroughly qualified organizations could not fail to affect the methods of constructing and maintaining roads in the smaller units of government, and if, through federal cooperation, the greater portion of our present huge outlay of $300,000,000 a year is directed in proper channels under competent supervision, the results in the form of tangible improvements will be amazing.

By confining the expenditure of the joint fund supplied by the federal government and the respective State governments to construction rather than to maintenance, tangible and durable roads will be provided to take the place of those upon which untold millions have been expended for temporary patchwork in the past. If year by year a steadily growing mileage of firm, smooth, well-constructed roads exist as evidence to show that every dollar of federal and State money jointly expended has been productive of results, it will not only go far toward providing convenient highways for traffic, but will, like the example of good management and skilled methods already cited, have a most beneficial influence upon the lesser units of government in demonstrating the advantages of durable construction.

While the primary purpose of the government in entering upon the policy of federal aid is to secure the construction of systems of highways which are urgently needed, it should not forego the opportunity and the duty to require on the part of the States that they adequately maintain every mile of road constructed with the aid of federal money. If legislation is framed so as to bring about such continuous and efficient maintenance a great benefit to the people will have been assured, as it is now generally recognized that because of lax administration and mistaken economy millions of dollars worth of well-constructed roads are disintegrating under the destructive action of heavy traffic. The federal government should not expend its revenues for maintenance, as by so doing it would not add to the stock of good roads, but it can make conditions which will bring about the desired results and leave the federal revenues free for the great task of cooperating in the building of improved roads.

It is essential to the normal development of transportation facilities that the public roads of each State shall be coordinated and correlated with the public roads of the adjoining States. In the absence of the correlating influence which government participation may provide it is probable that the development of the road system of the nation as a whole would be haphazard and uneconomical. Aside from the correlation of the actual roads there is a pressing need for a centralized correlating influence to bear upon the preparation of plans and specifications, the systems of record and cost accounting, and the other important details of operation, so that there may be simplicity, order, and economy in all phases of the work in which the federal government may participate.

It has been repeatedly estimated that 20 per cent of the roads may be so designated and improved as to carry from 80 to 85 per cent of the traffic. It may be assumed that the highway department of each State, representing both county and State interests, acting in cooperation with the federal government representatives, will select for improvement those roads which will best serve the traffic needs of the State and its local subdivisions. This unbiased selection would give to each particular section of country the kind and the distribution of road improvement as would tend, with the least percentage of surfaced roads, to care adequately for traffic needs. It might occur that in one section of the country the linking together of great through routes or trunk lines are needed, and that in another section of the country radial roads from important centers will best serve traffic needs, but however this may be, it would follow that those roads of most importance would first be improved, and that ultimately the traffic needs would be met by the smallest practicable surfaced road mileage.

It is manifestly important that the federal government shall deal with a definite and responsible agency in carrying out the policy of federal aid to road improvement. There are, besides the federal government, four distinct governmental units, namely, the State, the county, the township, and the municipality. As the primary purpose of federal aid is to improve country roads, the municipality need not be considered in this connection. There are by the latest count 3,000 counties, and it is estimated that there are about 30,000 townships, in the United States. Clearly it would be impracticable for the government to enter into any joint arrangement or to undertake to properly safeguard and check government expenditures in cooperation with 30,000, or even 3000 distinct agencies. It would therefore seem essential that the government deal only with the State governments in the working out of this policy. Furthermore, as the committee has already pointed out, it is necessary that systematic and skilled supervision be encouraged and extended, and it is impracticable to secure such supervision with any degree of uniformity except through the State governments acting through their highway departments.

No policy of federal aid should be adopted which does not permit the retention by the States of the fullest measure of control consistent with the necessary inspection and safeguarding which is customary with all federal appropriations. This balance of powers and duties as between the federal government and the States can readily be accomplished by leaving to the States the initiative in determining whether or not they desire to avail themselves of government aid, the direct supervision of every step of the construction and improvement, leaving only to the federal government the fullest measure of latitude in the way of inspection and approval at each step of the undertaking. This should provide, at the same time, harmony and efficiency without overlapping of duties and without clashing of interests or authority.

While the contribution on the part of the federal government should be substantial, so that results of some magnitude might be accomplished, such contribution should impose upon the States the duty of contributing in at least as large a measure, so that there may be no insidious paternalism established, which would stifle local initiative and self-help. If the federal government were to enter upon the building outright of a system of national highways, the temptation would be great on the part of States and their subdivisions to cease or curtail their own work of improvement in the hope that the federal government would ultimately come and make the improvements for them. Furthermore, the imposing upon the States of the duty of making substantial contribution will serve to automatically modify the demands upon the federal treasury, as excessive demands upon the federal treasury under these conditions would at the same time entail equally excessive demands upon the States. An unconditional payment out of the federal treasury would open the door to the most pernicious and dangerous "pork barrel" legislation possible to devise, as its appeal would be so universal and its demand so insistent that representatives in the federal congress would find it exceedingly difficult to square their sense of duty with their sense of political expediency.

Some plan must be adopted at the outset for determining what proportion of federal appropriation shall go to each State. In arriving at the most feasible and equitable plan, consideration must be given to those factors which are intimately related to the public roads. First, it must be considered that primarily the road is designed for the use of people, and it would therefore seem most equitable that population should form a basic factor in determining the distribution of appropriations. A secondary purpose of the public road is the development of land so that its riches may be made accessible for the use and benefit of man, and to this end area, which would represent the great sections of country yet to be developed, should be given consideration. Along our eastern seaboard population is dense, available land is scarce, while in the great domain west of the Mississippi River large areas of productive land are comparatively thinly populated, but are capable of yielding rich returns under suitable development. It would therefore seem that if the interests of the east are protected by the factor of population, the interests of the west should receive consideration through including area as a factor of apportionment. Finally, the direct interest of the federal government, as represented by the great mileage of rural delivery and star routes for the transportation of mail and parcel post should have some weight in the granting of federal funds, for certainly the federal government has a right to expect that its mail routes will be benefited by this general scheme of improvement, and so it would seem that the mileage of rural delivery and star routes should form another factor in the apportionment of appropriations.

The committee believes that a comprehensive plan extending over a period of years is infinitely preferable to a measure which provides a plan and an appropriation for a single year. The committee believes furthermore that a small appropriation should inaugurate the undertaking and that this appropriation should increase by degrees over the period covered by the act so that there may be a logical and thoroughly sound development of the work. A measure that provided for but a single year of operation would make no allowance for the necessity of developing and perfecting organization among the States suitable to carry on this work and for the formulation and agreement between the federal government and the States on the administrative procedure to most efficiently carry out the purposes of the act. It would afford no just and reasonable test of efficiency, because it would be humanly impossible in the space of a single year to carry out the great preliminary work and to accomplish results of an actual constructive character which would stand as a justification of federal participation. It would therefore be most likely that criticism would result, that a change in the form of federal legislation would be brought about, and that from year to year we should have the confusion and inefficiency resulting from constant legislative changes. The provision of a small appropriation in the beginning, gradually increasing to a fairly considerable amount, would not only make for efficiency in the expenditure of the appropriations but would safeguard the federal treasury by acting as a preventive to the voting of large appropriations to meet popular demands from year to year. With a definite program established covering a period of years there would be every reason to hope that this vexing question will have been taken care of, at least for a time.

So firmly is the committee convinced of the necessity for skilled supervision on the part of the several States that it feels justified in recommending that no federal aid shall be granted except to States which have established highway departments, other than that, until a sufficient time has elapsed after the passage of this act to enable the legislatures to meet and take proper action, no State should be discriminated against. After a State legislature has met in regular session and has had an opportunity to establish a highway department and to conform to federal requirements in this respect, it should no longer be excused from complying with those requirements. State supervision is proving by far the most effective means in the several States for the construction of improved roads, and it is extending its influence year by year. If government participation serves no other purpose than to further this trend away from extreme localization it will have accomplished a lasting benefit to the American people.

FEDERAL AID ROAD ACT OF 1916

PUBLIC LAW—No. 156— 64TH CONGRESS

AN ACT To provide that the United States shall aid the States in the Construction of rural post roads, and for other purposes

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the Secretary of Agriculture is authorized to cooperate with the States, through their respective State highway departments, in the construction of rural post roads; but no money apportioned under this Act to any State shall be expended therein until its legislature shall have assented to the provisions of this Act, except that, until the final adjournment of the first regular session of the legislature held after the passage of this Act, the assent of the governor of the State shall be sufficient. The Secretary of Agriculture and the State highway department of each State shall agree upon the roads to be constructed therein and the character and method of construction: *Provided,* That all roads constructed under the provisions of this Act shall be free from tolls of all kinds.

SEC. 2. That for the purpose of this Act the term "rural post road" shall be construed to mean any public road over which the United States mails now are or may hereafter be transported, excluding every street and road in a place having a population, as shown by the latest available federal census, of two thousand five hundred or more, except that portion of any such street or road along which the houses average more than two hundred feet apart; the term "State highway department" shall be construed to include any department of another name, or commission, or official or officials, of a State empowered, under its laws, to exercise the functions ordinarily exercised by a State highway department; the term "construction" shall be construed to include reconstruction and improvement of roads; "properly maintained" as used herein shall be construed to mean the making of needed repairs and the preservation of a reasonably smooth surface considering the type of the road; but shall not be held to include extraordinary repairs, nor reconstruction; necessary bridges and culverts shall be deemed parts of the respective roads covered by the provisions of this Act.

SEC. 3. That for the purose of carrying out the provisions of this Act there is hereby appropriated, out of any money in the

Treasury not otherwise appropriated, for the fiscal year ending June thirtieth, nineteen hundred and seventeen, the sum of $5,000,000; for the fiscal year ending June thirtieth, nineteen hundred and eighteen, the sum of $10,000,000; for the fiscal year ending June thirtieth, nineteen hundred and nineteen, the sum of $15,000,000; for the fiscal year ending June thirtieth, nineteen hundred and twenty, the sum of $20,000,000; and for the fiscal year ending June thirtieth, nineteen hundred and twenty-one, the sum of $25,000,000. So much of the appropriation apportioned to any State for any fiscal year as remains unexpended at the close thereof shall be available for expenditure in that State until the close of the succeeding fiscal year, except that amounts apportioned for any fiscal year to any State which has not a State highway department shall be available for expenditure in that State until the close of the third fiscal year succeeding the close of the fiscal year for which such apportionment was made. Any amount apportioned under the provisions of this Act unexpended at the end of the period during which it is available for expenditure under the terms of this section shall be reapportioned, within sixty days thereafter, to all the States in the same manner and on the same basis, and certified to the Secretary of the Treasury and to the State highway departments and to the governors of States having no State highway departments in the same way as if it were being apportioned under this Act for the first time: *Provided*, That in States where the constitution prohibits the State from engaging in any work of internal improvements, then the amount of the appropriation under this Act apportioned to any such State shall be turned over to the highway department of the State or to the governor of said State to be expended under the provisions of this Act and under the rules and regulations of the Department of Agriculture, when any number of counties in any such State shall appropriate or provide the proportion or share needed to be raised in order to entitle such State to its part of the appropriation apportioned under this Act.

SEC. 4. That so much, not to exceed three per centum, of the appropriation for any fiscal year made by or under this Act as the Secretary of Agriculture may estimate to be necessary for administering the provisions of this Act shall be deducted for that purpose, available until expended. Within sixty days after the close of each fiscal year the Secretary of Agriculture shall determine what part, if any, of the sums theretofore deducted for administering the provisions of this Act will not be needed for that purpose and apportion such part, if any, for the fiscal year then current in the same manner and on the same basis, and certify it to the Secretary of the Treasury and to the State highway departments, and to the governors of States having no

State highway departments, in the same way as other amounts authorized by this Act, to be apportioned among all the States for such current fiscal year. The Secretary of Agriculture, after making the deduction authorized by this section, shall apportion the remainder of the appropriation for each fiscal year among the several States in the following manner: One-third in the ratio which the area of each State bears to the total area of all the States; one-third in the ratio which the population of each State bears to the total population of all the States, as shown by the latest available Federal census; one-third in the ratio which the mileage of rural delivery routes and star routes in each State bears to the total mileage of rural delivery routes and star routes in all the States, at the close of the next preceding fiscal year, as shown by the certificate of the Postmaster General, which he is directed to make and furnish annually to the Secretary of Agriculture.

SEC. 5. That within sixty days after the approval of this Act the Secretary of Agriculture shall certify to the Secretary of the Treasury and to each State highway department and to the governor of each State having no State highway department the sum which he has estimated to be deducted for administering the provisions of this Act and the sum which he has apportioned to each State for the fiscal year ending June thirtieth, nineteen hundred and seventeen, and on or before January twentieth next preceding the commencement of each succeding fiscal year shall make like certificates for such fiscal year.

SEC. 6. That any State desiring to avail itself of the benefits of this Act shall, by its State highway department, submit to the Secretary of Agriculture project statements setting forth proposed construction of any rural post road or roads therein. If the Secretary of Agriculture approve a project, the State highway department shall furnish to him such surveys, plans, specifications, and estimates therefor as he may require: *Provided, however,* That the Secretary of Agriculture shall approve only such projects as may be substantial in character and the expenditure of funds hereby authorized shall be applied only to such improvements. Items included for engineering, inspection, and unforeseen contingencies shall not exceed ten per centum of the total estimated cost of the work. If the Secretary of Agriculture approve the plans, specifications, and estimates, he shall notify the State highway department and immediately certify the fact to the Secretary of the Treasury. The Secretary of the Treasury shall thereupon set aside the share of the United States payable under this Act on account of such project, which shall not exceed fifty per centum of the total estimated cost thereof. No payment of any money apportioned under this Act shall be made on any project until such statement of the project, and the plans, specifications, and estimates therefor, shall have been submitted to and approved by the Secretary of Agriculture.

When the Secretary of Agriculture shall find that any project so approved by him has been constructed in compliance with said plans and specifications he shall cause to be paid to the proper authority of said State the amount set aside for said project: *Provided*, That the Secretary of Agriculture may, in his discretion, from time to time make payments on said construction as the same progresses, but these payments including previous payments, if any, shall not be more than the United States' pro rata part of the value of the labor and materials which have been actually put into said construction in conformity to said plans and specifications; nor shall any such payment be in excess of $10,000 per mile, exclusive of the cost of bridges of more than twenty feet clear span. The construction work and labor in each State shall be done in accordance with its laws, and under the direct supervision of the State highway department, subject to the inspection and approval of the Secretary of Agriculture and in accordance with the rules and regulations made pursuant to this Act.

The Secretary of Agriculture and the State highway department of each State may jointly determine at what times, and in what amounts, payments, as work progresses, shall be made under this Act. Such payments shall be made by the Secretary of the Treasury, on warrants drawn by the Secretary of Agriculture, to such official, or officials, or depository, as may be designated by the State highway department and authorized under the laws of the State to receive public funds of the State or county.

SEC. 7. To maintain the roads constructed under the provisions of this Act shall be the duty of the States, or their civil subdivisions, according to the laws of the several States. If at any time the Secretary of the Agriculture shall find that any road in any State constructed under the provisions of this Act is not being properly maintained he shall give notice of such fact to the highway department of such State and if within four months from the receipt of said notice said road has not been put in a proper condition of maintenance then the Secretary of Agriculture shall thereafter refuse to approve any project for road construction in said State, or the civil subdivision thereof, as the fact may be, whose duty it is to maintain said road, until it has been put in a condition of proper maintenance.

SEC. 8. That there is hereby appropriated and made available until expended, out of any moneys in the National Treasury not otherwise appropriated, the sum of $1,000,000 for the fiscal year ending June thirtieth, nineteen hundred and seventeen, and each fiscal year thereafter, up to and including the fiscal year ending June thirtieth, nineteen hundred and twenty-six, in all $10,000,000, to be available until expended under the supervision of the Secretary of Agriculture, upon request from the proper officers of the State, Territory, or county for the survey, construction, and maintenance of roads and trails within or only partly within the national forests, when necessary for the use and development of resources upon which communities within and adjacent to the national forests are dependent: *Provided*, That the State, Territory, or county shall enter into a cooperative agreement with the Secretary of Agriculture for the survey, construction, and maintenance of such roads or trails upon a basis equitable to both the State, Territory, or county, and the United States: *And provided also*, That the aggregate expenditures in any State, Territory, or county shall not exceed ten per centum of the value, as determined by the Secretary of Agriculture, of the timber and forage resources which are or will be available for income upon the national forest lands within the respective county or counties wherein the roads or trails will be constructed; and the Secretary of Agriculture shall make annual report to Congress of the amounts expended hereunder.

That immediately upon the execution of any cooperative agreement hereunder the Secretary of Agriculture shall notify the Secretary of the Treasury of the amount to be expended by the United States within or adjacent to any national forest thereunder, and beginning with the next fiscal year and each fiscal year thereafter the Secretary of the Treasury shall apply from any and all revenues from such forest ten per centum thereof to reimburse the United States for expenditures made under such agreement until the whole amount advanced under such agreement shall have been returned from the receipts from such national forest.

SEC. 9. That out of the appropriations made by or under this Act, the Secretary of Agriculture is authorized to employ such assistants, clerks, and other persons in the city of Washington and elsewhere, to be taken from the eligible lists of the Civil Service Commission, to rent buildings, outside of the city of Washington, to purchase such supplies, material, equipment, office fixtures, and apparatus, and to incur such travel and other expense as he may deem necessary for carrying out the purposes of this Act.

SEC. 10. That the Secretary of Agriculture is authorized to make rules and regulations for carrying out the provisions of this Act.

SEC. 11. That this Act shall be in force from the date of its passage.

Approved, July 11, 1916.

RULES AND REGULATIONS OF THE SECRETARY OF AGRICULTURE FOR CARRYING OUT THE FEDERAL-AID ROAD ACT. (EXCEPT SECTION 8 THEREOF)

Issued September 1, 1916

Regulation 1.—Definitions

For the purposes of these regulations, the following terms shall be construed, respectively, to mean—

SECTION 1. *The Federal-aid road act, or the act.*—An act of Congress entitled, "An Act to provide that the United States shall aid the States in the construction of rural post roads, and for other purposes," approved July 11, 1916. (Public, No. 156, 64th Congress.)

SEC. 2. *The Secretary.*—The Secretary of Agriculture of the United States.

SEC. 3. *Office of Public Roads.*—The Office of Public Roads and Rural Engineering of the United States Department of Agriculture.

SEC. 4. *Ten per cent fund.*—Items for engineering, inspection, and unforeseen contingencies, not exceeding 10 per cent of the total estimated cost of the work.

SEC. 5. *Authorized representatives of the Secretary.*—The Director of the Office of Public Roads and such other officials and employees thereof as he may designate from time to time.

Regulation 2.—Application of Regulations

SECTION 1. These regulations apply to all provisions, except section 8, of the act and shall not be applied to section 8 unless hereafter authorized or required by order of the Secretary.

SEC. 2. These regulations shall apply as fully where the State can not constitutionally engage in any work of internal improvements as in any other case, when any number of counties in such State shall appropriate or provide the proportion of share needed to be raised in order to entitle such State to its part of the appropriation apportioned under the act.

Regulation 3.—Information for the Secretary

SECTION 1. Before an agreement is made upon any road or roads to be constructed in a State, or the character and method of construction, upon request of the Secretary there shall be furnished to him, by or on behalf of the State, general information as to its laws affecting roads and the authority of the State and local officials in reference to the construction and maintenance of roads; as to schemes for future construction; and as to provisions made, or to be made, for constructing and maintaining roads upon which it is contemplated that the expenditure of money appropriated by or under the act will be proposed. The information furnished shall be sufficient to enable the Secretary to determine whether it is likley that the money apportioned to the State will be expended, and the roads constructed will be properly maintained, in accordance with the terms of the act.

SEC. 2. Information requested by the Secretary or his authorized representative, relating to the maintenance of roads constructed under the provisions of the act, shall be furnished, from time to time, by the State highway departments, on forms supplied by the Office of Public Roads.

SEC. 3. Data furnished by or on behalf of a State shall be supplemented by such reports of the Office of Public Roads as the Secretary may from time to time require before he decides whether the State has complied with the terms of the act or has presented a project statement which should be approved.

Regulation 4.—Project Statements

SECTION 1. A project statement shall contain all information necessary to enable the Secretary to ascertain (*a*) whether the project conforms to the requirements of the act; (*b*) whether adequate funds, or their equivalent, are or will be available by or on behalf of the State for construction; (*c*) what purpose the project will serve and how it correlates with the other highway work of the State; (*d*) the administrative control of, and responsibility for, the project; (*e*) the practicability and economy of the project from an engineering and construction standpoint; (*f*) the adequacy of the plans and provisions for proper maintenance of roads; and (*g*) the approximate amount of Federal aid desired. With each statement there shall be submitted for the approval of the Secretary copies of the form of contract, together with all documents referred to therein or made part thereof, and of the contractor's bond which it is proposed to use on the project. No alteration of such forms shall be made until it is approved by the Secretary.

SEC. 2. Suitable forms for project statements will be supplied by the Office of Public Roads.

SEC. 3. Project statements for any fiscal year may be submitted at any time after the apportionment for that year shall have been made.

SEC. 4. Projects will be deemed preferred and recommended for approval by the State highway department in the order in which the project statements are submitted, unless it be otherwise specified in writing, but the Secretary may, in his discretion, consider the projects in a different order.

SEC. 5. Each project statement shall be accompanied by a sketch map showing the location of the proposed project and all main contiguous transportation features.

SEC. 6. Suitable samples of materials suggested for use in the construction of a project shall be submitted to the Office of Public Roads, whenever requested by it, for examination prior to the Secretary's decision on the project statement.

SEC. 7. Where any part of the cost of a project is to be furnished by a county or other local subdivision or subdivisions of a State, the project statement shall be accompanied by certified copy of each resolution or order, if any, of the appropriate local officials respecting the funds which are or will be made available, or respecting the supervision of the construction of the road and of the expenditure of the money provided or to be provided for paying such cost.

Regulation 5.—Surveys, Plans, Specifications, and Estimates.

SECTION 1. Surveys and plans shall show, in convenient form and sufficient detail, according to accepted engineering practice, necessary data in connection with the specifications and estimates, to enable the Secretary to ascertain and pass upon location, grades, drainage, bridges, other structures, special and unusual features, the work to be performed, and the probable cost thereof.

SEC. 2. Specifications shall set forth the proposed method of construction, type of construction, materials to be used, and other essentials, in such detail as to afford complete knowledge of all steps to be taken in the construction of the project.

SEC. 3. The estimate for each project shall show the estimated quantity and cost of each item of construction in detail and, separately, the 10 per cent fund, and shall not include any expense of advertising.

SEC. 4. Rights of way necessary for any project shall be provided, and any incidental damages to adjoining property due to construction work paid by or on behalf of the State, and the expense thereof shall not be included in the estimate or paid in any part, directly or indirectly, by the Federal Government.

SEC. 5. Grade crossings shall be avoided where practicable. The estimated cost of eliminating a grade crossing shall not include any amount the State, county, or other civil subdivision has received, is to receive, or is entitled to receive, directly or indirectly, as reimbursement or payment from the owner of a public utility for or on account of such elimination.

SEC. 6. No part of the expense of making surveys, plans, specifications, or estimates, by or on behalf of the State prior to the beginning of construction work, shall be included in the estimate or paid by the Federal Government.

SEC. 7. When plans, specifications, and estimates have been approved by the Secretary, no alteration thereof shall be made without his approval.

SEC. 8. For all projects for which statements are submitted after December 31, 1916, standards governing the form and arrangement of plans, specifications, and estimates will be hereafter prescribed and promulgated by the Secretary.

Regulation 6.—Project Agreements

SECTION 1. A project agreement between the State highway department and the Secretary shall be executed, in triplicate, on a form furnished by him, previous to commencement of the construction of the project.

Regulation 7.—Contracts

SECTION 1. No part of the Federal money set aside on account of any project shall be paid until it has been shown to the satisfaction of the Secretary that adequate means, either by advertising or by other devices appropriate for the purpose, were employed, prior to the beginning of construction, to insure the economical and practical expenditure of such money.

SEC. 2. Immediately on publication of advertisements, copies thereof shall be furnished to the Office of Public Roads.

SEC. 3. Bids shall be in such form that the unit prices at which the various services are to be performed and the various materials furnished will be clearly shown.

SEC. 4. Copy of the tabulated bid prices, showing the unit prices and the totals of each bid for every project, shall be furnished promptly to the Office of Public Roads.

SEC. 5. In advance of the acceptance of any bid, sufficient notice of the time and place the contract is to be awarded shall be given to the Office of Public Roads to enable it, if it so desire, to have a representative present. When a bid has been accepted prompt notice thereof shall be given to the Office of Public Roads.

SEC. 6. If the contract be awarded to any other than the lowest responsible bidder, the Federal Government shall not pay more than its pro rate share of the lowest responsible bid, unless it be satisfactorily shown that it was advantageous to the work to accept the higher bid.

SEC. 7. A copy of each contract as executed shall be immediately certified by the State highway department and furnished to the Office of Public Roads.

SEC. 8. The specifications and plans shall be made a part of the contract.

SEC. 9. No alteration in such contract shall be made without the approval of the Secretary.

Regulation 8.—Construction Work and Labor

SECTION 1. Suitable samples of materials to be used in construction work shall be submitted by or on behalf of the State highway department, to the Office of Public Roads whenever requested.

SEC. 2. Unless otherwise stipulated in writing by the Secretary or his authorized representative, materials for the construction of any project shall, prior to use, be tested for conformity with specifications, according to methods prescribed or approved by the Office of Public Roads.

SEC. 3. Unless otherwise specifically stipulated in the project agreement, bridges, viaducts and underpasses shall have clear width of roadway of not less than 16 feet and clear head room of not less than 14 feet for a width of 8 feet at the center.

SEC. 4. No part of the money apportioned under the act shall be used, directly or indirectly, to pay, or to reimburse a State, county, or local subdivision for the payment of any premium or royalty on any patented or proprietary material, specification, process, or type of construction, unless purchased or obtained on open actual competitive bidding at the same or a less cost than unpatented articles or methods equally suitable for the same purpose.

SEC. 5. The supervision of each project by the State highway department shall include adequate inspection throughout the course of construction.

SEC. 6. Written notice of commencement and completion of construction work on any project shall be given promptly by the State highway department to the Office of Public Roads.

SEC. 7. Reports of the progress of construction, showing force employed and work done, shall be furnished, from time to time, whenever requested by the Secretary or his authorized representative.

SEC. 8. Labor, teams, materials, and equipment furnished, in lieu of money, by or on behalf of the State highway department on construction work shall be used only on such terms and conditions as are set forth in the project agreement.

Regulation 9.—Records and Cost Keeping

SECTION 1. A separate account for each project shall be so kept, by or under the direction of the State highway department as to enable the secretary, or his authorized representative, to ascertain at any time the expenditures on and the liabilities against the project and, separately, the condition of the 10 per cent fund.

SEC. 2. Such other records of contract and force account work, and of inspections and tests by or on behalf of the State, shall be kept, by or under the direction of the State highway department, as will enable the Secretary, or his authorized representative, at any time to determine the condition of the construction and maintenance of, and the cost to the State and the Federal Government of the construction work and labor done on any project.

SEC. 3. The accounts and records, together with all supporting documents, shall be open, at all times, to the inspection of the Secretary, or his authorized representative, and copies thereof shall be furnished when requested.

SEC. 4. Certified copies of pay rolls on force account work and of all vouchers for other expenditures shall be furnished, whenever requested by the Secretary or his authorized representative.

SEC. 5. Whenever requested by the Secretary or his authorized representative, unit costs on any project shall be kept on forms furnished by the Office of Public Roads.

Regulation 10.—Payments

SECTION 1. Vouchers, in the form provided by the Secretary and certified as therein prescribed, showing amounts expended on any project and amount claimed to be due from the Federal Government on account thereof, shall be submitted by the State highway department to the Office of Public Roads, either after completion of construction of the project or, if the Secretary has determined to make payments as the construction progresses, at intervals of not less than one month.

Regulation 11.—Office of Public Roads

SECTION 1. Papers and documents required by the act or these regulations to be submitted to the Secretary may be delivered to the Office of Public Roads and from the date of such delivery shall be deemed submitted.

APPROPRIATIONS FOR ROADS AND TRAILS WITHIN OR PARTLY WITHIN THE NATIONAL FORESTS

The annual appropriation of $1,000,000 for roads within or partly within the national forests has been apportioned by the Secretary of Agriculture as follows: 10 per cent of the amount available annually is witheld as a contingent fund. One-half of the remainder is allotted to the States in amounts based on the area of national forests in each. The other half is apportioned on the basis of the estimated value of timber and forage resources which the national forests contain. Amounts apportioned but unexpended within three years, and any balance of the contingent fund which remains unapportioned at the end of each year, will be reapportioned on the same basis as the original allotments.

Certain States have been grouped together in making apportionments. Group W comprises Florida, Michigan, Minnesota, Nebraska, North Dakota and Oklahoma. Group E comprises Georgia, Maine, New Hampshire, North and South Carolina, Tennessee, Virginia and West Virginia.

The appropriations are for fiscal years. The tabulated figures for 1917 and 1918 are for the twelve months ending on June 30 of those years.

	1917	1918		1917	1918
Alaska............	$46,280	$46,354	New Mexico.....	$42,622	$42,495
Arizona............	59,795	58,604	Oregon...........	127,794	128,111
Arkansas...........	11,294	9,803	South Dakota....	8,115	8,092
California..........	140,763	140,988	Utah.............	40,982	41,167
Colorado...........	62,335	62,575	Washington......	91,739	91,944
Idaho..............	108,010	108,730	Wyoming........	40,566	40,684
Montana...........	69,901	70,042	Group W.........	9,552	9,995
Nevada............	19,195	19,296	Group E.........	21,057	21,120

RULES AND REGULATIONS OF THE SECRETARY OF AGRICULTURE UNDER SECTION 8 OF THE FEDERAL-AID ROAD ACT

Issued September 1, 1916

Regulation 1.—Definitions

For the purposes of these regulations the following terms shall be construed, respectively, to mean:.

SECTION 1. *Act.* Section 8 of an act of Congress entitled "An act to provide that the United States shall aid the States in the construction of rural post roads, and for other purposes," approved July 11, 1916. (Public, No. 156, 64th Congress.)

SEC. 2. *Secretary.* The Secretary of Agriculture of the United States.

SEC. 3. *Office of Public Roads.* The Office of Public Roads and Rural Engineering of the United States Department of Agriculture.

SEC. 4. *Local authority.* The State, Territory, or county, jointly or severally, making application for the survey and construction of a road or entering into a cooperative agreement with the Secretary.

SEC. 5. *State.* Any State or Territory.

SEC. 6. *Road.* A road, trail, or bridge.

SEC. 7. *National forest road.* A road constructed or to be constructed in cooperation with the local authorities under the direct supervision of the Secretary of Agriculture and paid for, in whole or in part, out of moneys made available by the act.

SEC. 8. *Cooperative road.* A road constructed or to be constructed under State, Territory, or county supervision and under cooperative agreement as provided in the act, but paid for out of funds other than those appropriated by the act.

SEC. 9. *Construction.* Reconstruction and improvement of roads, as well as original construction.

SEC. 10. *Maintenance* or *properly maintain.* The making of needed repairs and the preservation of a reasonably smooth surface, considering the type of road, but not extraordinary repairs or reconstruction.

SEC. 11. *State highway department.* Any department of another name, or commission, or official or officials, of a State empowered, under its laws, to exercise the functions ordinarily exercised by a State highway department.

Regulation 2.—Apportionment

SECTION 1. Ten per cent of each annual appropriation shall be withheld as a special fund, from which, as directed by the Secretary, the apportionment to any State as hereafter provided may be increased, and from which there shall be paid such amounts as the Secretary may find necessary for the general administration of the provisions of the act. The remaining ninety per cent of each annual appropriation shall be apportioned to the States as follows: One-half on the basis that the aggregate area of the lands of the United States in the national forests in each State bears to the total land area of such State, and one-half in the proportion that the estimated value of timber and forage resources of the national forests in such State bears to the total value of timber and forage resources of the national forests of all the States: *Provided, however,* That in such apportionment the States of Florida, Michigan, Minnesota, Nebraska, North Dakota, and Oklahoma shall be considered as a unit of apportionment, and the States within which lands have been acquired by the United States under the provisions of the act of March 1, 1911 (36 Stat., 961), entitled "An act to enable any State to cooperate with any other State or States or with the United States for the protection of watersheds of navigable streams, and to appoint a commission for the acquisition of lands for the purpose of conserving the navigability of navigable rivers," known as the Weeks law, shall also be considered as a unit of apportionment.

SEC. 2. The apportionment for the fiscal year ending June 30, 1917, shall be made as of the date of the approval of these regulations, and on or before the 1st day of January next preceding the commencement of each succeeding fiscal year the Secretary will make like apportionment for such fiscal year.

SEC. 3. Any amounts apportioned to the States as herein provided remaining unexpended for a period of three years after such apportionment may be reapportioned by the Secretary to the several States in the manner provided for original apportionment.

Regulation 3.—Applications

SECTION 1. Application for the survey, construction, and maintenance of roads under the act shall be made by the proper local authority to the Secretary upon forms furnished by the Forest Service and filed in the district office of the Forest Service for the district within which the proposed road is located. Any application by a county in a State having a State highway department shall, before filing, be referred to such department for its recommendation, which shall be filed with the application.

SEC. 2. Applications for the fiscal year ending June 30, 1917, shall be filed on or before October 1, 1916, and for each succeeding fiscal year on or before the 1st day of January next preceding such fiscal year.

SEC. 3. Each application shall contain: (*a*) Satisfactory evidence of authority to make application on behalf of the State, Territory, or county, and to enter into a cooperative agreement with the Secretary for the survey, construction, and maintenance of the proposed road; (*b*) a statement of the public needs to be served by the proposed road and the manner in and extent to which such road is necessary for the use and development of the resources upon which communities within or adjacent to the national forests are dependent; (*c*) a statement showing (1) the general location of the proposed road, (2) its termini, length, grades, and estimated cost, and (3) the name, population, and location with respect to the proposed road of each community that would be benefited thereby; and (*d*) proposals for cooperation, giving in detail the amount and extent of the cooperation offered, whether in money, materials, labor, or the construction of a cooperative road and whether cooperative moneys will be held and disbursed by the local authority or will be deposited in the United States Treasury in accordance with the provisions of the act of Congress approved June 30, 1914 (38 Stat., 415, 430), entitled "An act making appropriations for the Department of Agriculture for the fiscal year ending June 30, 1915," creating a special fund of contributions for cooperative forest work, available until expended, for the payment of the expenses of such work and for refunds to the contributors of amounts paid by them in excess of their share of such work.

SEC. 4. Applications which are not approved for the fiscal year for which made will be retained, and unless modified or withdrawn by the applicant will be considered for succeeding fiscal years.

Regulation 4.—Selection of Projects

SECTION 1. The Forest Service shall prepare: (*a*) A project plan for each State, providing, as far as practicable, for a comprehensive road system in the national forests, showing in the order of their importance the roads within or partly within the national forests which it believes should be constructed; (*b*) maps showing the road system for each national forest and delimiting the projects listed, as provided in section 3 hereof, with a mark or marks of identification for each; and (*c*) a statement for each county in which there is a national forest, showing the maximum amount which may be expended therein under the act. Such project plans, maps, and statements shall be submitted to the Secretary for approval, and after such approval shall be transmitted to the Office of Public Roads for its information.

SEC. 2. Unless satisfactory data are already available, reconnoissance surveys and preliminary cost estimates shall be made by or under the direction of the Office of Public Roads of all road projects for which proper application has been made.

SEC. 3. A list of the projects applied for, arranged as to each State in the order in which construction is recommended, shall be forwarded each year for presentation to the Secretary. The project list as approved by the Secretary shall determine the order of construction for each year.

Regulation 5.—Coöperative Agreement

SECTION 1. Upon the approval of any project list, a cooperative agreement for execution by the Secretary and the local authority shall be prepared by the solicitor from data furnished by the Forest Service and the Office of Public Roads for each of those projects, in the order listed, for which funds are or will be available, and shall provide for: (*a*) Surveys, plans, construction, and maintenance of the project to be done in accordance with these rules and regulations; (*b*) amount, value, and character of cooperation; (*c*) furnishing of labor and materials, the deposit of cooperative funds in the Treasury, or the disbursement of such funds by the local authority; (*d*) supervision and inspection during construction and approval upon completion; (*e*) final accounting to each party to the agreement of all labor or materials furnished and all moneys expended under the agreement; and (*f*) such other terms as in the opinion of the Secretary should be included.

SEC. 2. The basis of cooperation shall be the reconnoissance survey estimate of the cost of final survey and construction. Cooperation shall be expressed as far as feasible in percentages. If the location survey estimates exceed the reconnoissance estimates by 25 per cent or more, the Secretary shall so notify the local authority, and at any time within 30 days either party to the agreement may apply for a modification thereof. If modifications can be agreed upon, a supplementary agreement, if necessary, shall be drawn; otherwise, either party may withdraw from the agreement upon 30 days' notice. In case of such excess, construction shall not be started nor advertisements made for bids until final agreement is reached.

SEC. 3. Each local authority will be required to cooperate as herein defined in an amount at least equal to 50 per cent of the estimated cost of the final survey and construction and the entire cost of maintenance of national forest roads, unless a satisfactory showing is made to the Secretary that such an amount of cooperation is inequitable. Cooperation by local authorities may be in the form of money, labor, materials, or the construction of coperative roads, and the amount and value thereof shall be fixed by the Secretary. Cooperation in the form of road construction will be accepted only when such cooperative road connects with and is an extension of a national forest road, and to the extent only that such road is necessary to furnish a connection between a national forest road and the general State, Territory, or county road system. Such cooperative road may be either within or without national forest boundaries.

Regulation 6.—Surveys, Construction, and Maintenance

SECTION 1. Upon the execution of a cooperative agreement the Office of Public Roads shall proceed with the survey and construction of the road in accordance with such cooperative agreement.

SEC. 2. National forest roads shall be constructed under the supervision of the Office of Public Roads, in accordance with plans prepared by it and approved by the Forest Service. The maintenance of such roads shall be under the supervision of the Office of Public Roads, unless otherwise provided in the agreement.

SEC. 3. Cooperative roads shall be constructed in accordance with plans made as provided in the cooperative agreement and approved by the Office of Public Roads and the Forest Service. Such roads shall be subject to approval by the Secretary on completion, and to inspection by the Office of Public Roads during construction and maintenance. Cooperative roads shall be maintained by the local authorities.

SEC. 4. If a cooperative road is not constructed as provided in the preceding section, or any road constructed under a cooperative agreement is not properly maintained in accordance with its terms, or there is failure to comply with any other of its terms, the Secretary will give notice of such fact to the proper local authority. If within four months from the receipt of such notice the terms of such agreement are not complied with, the Secretary will thereafter refuse to enter into any other cooperative agreement with such local authority until compliance has been made with the original agreement.

Regulation 7.—Accounting

SECTION 1. All Federal funds expended for road construction under the act and all cooperative funds which may be deposited in the United States Treasury in accordance with the act of Congress approved June 30, 1914 (38 Stat., 415, 430), mentioned in section 3 of regulation 3, shall be disbursed as directed by the Secretary of Agriculture.

SEC. 2. Cooperative funds used for the survey and construction of national forest roads but not deposited in the Treasury shall be disbursed by the local authority only upon vouchers approved by the Office of Public Roads.

SEC. 3. A separate account shall be kept, as directed by the Secretary, of all moneys disbursed for national forest roads showing the States and counties within which and the projects upon which such moneys have been expended, and the Secretary will furnish to the local authorities a detailed statement of such expenditures as soon as practicable after the completion of every project.

SEC. 4. Unless otherwise directed by the Secretary, records of the costs of survey and construction of all road projects, whether cooperative or national forest roads, shall be kept upon forms to be supplied by the Office of Public Roads. If the Secretary shall so direct, progress statements or reports shall be submitted from time to time to the Office of Public Roads on forms supplied by that office, and within 90 days after the completion of a project the local authority shall submit to the Secretary a final report of the project on a form supplied by the Office of Public Roads.

SEC. 5. Immediately upon the execution of a cooperative agreement the Secretary will notify the Secretary of the Treasury of the amount to be expended by the United States within or adjacent to any national forest thereunder, and upon the completion of each project and the closing of the project accounts relating thereto the Secretary will submit to the Secretary of the Treasury a statement of the total expenditures of Federal funds made on account thereof and the distribution of such expenditures to each national forest concerned.

FACTORS OF APPORTIONMENT TO STATES UNDER FEDERAL-AID ROAD ACT. APPROPRIATION FOR THE FISCAL YEAR 1917

STATE	AREA AS OF 1910 UNITED STATES CENSUS		POPULATION AS OF 1910 UNITED STATES CENSUS		STAR AND RURAL ROUTES SHOWN BY CERTIFICATE OF POSTMASTER GENERAL AS OF JUNE 30, 1916		PERCENTAGE APPORTIONMENT	SUM APPORTIONED
	Square miles	Percentage	Population	Percentage	Miles	Percent age		
Alabama	51,998	1.71796	2,138,093	2.33311	29,615	2.39111	2.14740	$104,148.90
Arizona	113,956	3.76500	204,354	0.22299	3,096	0.24997	1.41265	68,513.52
Arkansas	53,335	1.76214	1,574,449	1.71806	20,245	1.63458	1.70493	82,689.10
California	158,297	5.22999	2,377,549	2.59441	18,823	1.51976	3.11472	151,063.92
Colorado	103,948	3.43435	799,024	0.87191	10,781	0.87045	1.72557	83,690.14
Connecticut	4,965	0.16404	1,114,756	1.21644	6,721	0.54265	0.64104	31,090.44
Delaware	2,370	0.07830	202,322	0.22078	2,566	0.20718	0.16875	8,184.37
Florida	58,666	1.93827	752,619	0.82127	8,706	0.70292	1.15415	55,976.27
Georgia	59,265	1.95806	2,609,121	2.84711	43,397	3.50386	2.76968	134,329.48
Idaho	83,888	2.77158	325,594	0.35529	7,594	0.61314	1.24667	60,463.50
Illinois	56,665	1.87216	5,638,591	6.15290	69,860	5.64048	4.55518	220,926.23
Indiana	36,354	1.20110	2,700,876	2.94723	52,619	4.24844	2.79892	135,747.62
Iowa	56,147	1.85505	2,224,771	2.42770	58,943	4.75904	3.01393	146,175.60
Kansas	82,158	2.71442	1,690,949	1.84518	53,240	4.29858	2.95273	143,207.40
Kentucky	40,598	1.34132	2,289,905	2.49877	27,113	2.18910	2.00973	97,471.91
Louisiana	48,506	1.60259	1,656,388	1.80747	9,458	0.76364	1.39123	67,474.66
Maine	33,040	1.09161	742,371	0.81008	13,566	1.09531	0.99900	48,451.50
Maryland	12,327	0.40727	1,295,346	1.41350	11,194	0.90380	0.90819	44,047.22
Massachusetts	8,266	0.27310	3,366,416	3.67347	7,698	0.62153	1.52270	73,850.95
Michigan	57,980	1.91561	2,810,173	3.06650	49,981	4.03545	3.00585	145,783.72
Minnesota	84,682	2.79782	2,075,708	2.26504	46,384	3.74503	2.93596	142,394.06
Mississippi	46,865	1.54838	1,797,114	1.96103	24,646	1.98991	1.83311	88,905.84
Missouri	69,420	2.29357	3,293,335	3.59373	57,108	4.61088	3.49939	169,720.41
Montana	146,997	4.85664	376,053	0.41035	10,065	0.81264	2.02654	98,287.19
Nebraska	77,520	2.56119	1,192,214	1.30096	33,964	2.74224	2.20146	106,770.81
Nevada	110,690	3.65710	81,875	0.08934	2,935	0.23697	1.32780	64,398.30
New Hampshire	9,341	0.30862	430,572	0.46985	6,444	0.52029	0.43292	20,996.62
New Jersey	8,224	0.27171	2,537,167	2.76859	7,708	0.62234	1.22088	59,212.68
New Mexico	122,634	4.05171	327,301	0.35715	5,716	0.46151	1.62346	78,737.81
New York	49,204	1.62565	9,113,614	9.94489	48,773	3.93792	5.16949	250,720.27
North Carolina	52,426	1.73211	2,206,287	2.40753	36,358	2.93553	2.35839	114,381.92
North Dakota	70,837	2.34039	577,056	0.62969	21,548	1.73978	1.56996	76,143.06
Ohio	41,040	1.35592	4,767,121	5.20194	61,968	5.00328	3.85372	186,905.42
Oklahoma	70,057	2.31462	1,657,155	1.80831	37,145	2.99908	2.37400	115,139.00
Oregon	96,699	3.19485	672,765	0.73413	11,621	0.93828	1.62242	78,687.37
Pennsylvania	45,126	1.49092	7,665,111	8.36426	54,638	4.41146	4.75555	230,644.17
Rhode Island	1,248	0.04123	542,610	0.59210	1,093	0.08825	0.24053	11,665.71
South Carolina	30,989	1.02385	1,515,400	1.65362	21,851	1.76424	1.48057	71,807.64
South Dakota	77,615	2.56433	583,888	0.63715	22,362	1.80550	1.66899	80,946.02
Tennessee	42,022	1.38837	2,184,789	2.38407	40,731	3.28861	2.35368	114,153.48
Texas	265,896	8.78496	3,896,542	4.25195	62,181	5.02048	6.01913	291,927.81
Utah	84,990	2.80799	373,351	0.40740	3,806	0.30730	1.17423	56,950.15
Vermont	9,564	0.31599	355,956	0.38842	8,777	0.7086	0.47102	22,844.47
Virginia	42,627	1.40836	2,061,612	2.24966	31,045	2.50656	2.05486	99,660.71
Washington	69,127	2.28389	1,141,990	1.24615	11,350	0.91640	1.48215	71,884.28
West Virginia	24,170	0.79855	1,221,119	1.33250	14,417	1.16402	1.09836	53,270.46
Wisconsin	56,066	1.85237	2,333,860	2.54674	43,854	3.54076	2.64662	128,361.07
Wyoming	97,914	3.23499	145,965	0.15928	4,844	0.39110	1.26179	61,196.82
Total	3,026,719	100.00000	91,641,197	100.00000	1,238,548	100.00000	100.00000	$4,850,000.00

UNITED STATES OFFICE OF PUBLIC ROADS AND RURAL ENGINEERING

The Office of Road Inquiry was established by Congress in 1893 to investigate systems of road management and methods of road making, and to make public information on these subjects. During the twenty years following the establishment of the Road Office, these duties were gradually extended and broadened so as to include the physical and chemical testing of road materials, and the conducting of field experiments. In 1912, under the Post Office appropriation bill, Congress placed the construction and improvement of certain post roads under the supervision of this Office. The agricultural appropriation act of 1915 directed the Secretary of Agriculture to submit a plan for reorganizing the work of his Department. The plan he submitted became effective July 1, 1915. The Office of Public Roads became the Office of Public Roads and Rural Engineering, and took charge of all that part of the Department's agricultural work which partook in any way of an engineering nature. In 1916, the Secretary of Agriculture directed the Office to act for him in the routine administration of the Federal Aid Road Act.

Educational Work.—The work of the Office as now organized may be conveniently grouped into three general classes: (1) Educational or extension; (2) investigational or research; (3) administration of the Federal Aid Road Act.

The education work is conducted in four stages:

1. Reaching the people by means of lectures, addresses, the publication of bulletins, the exhibit of models, etc., and teaching them the economic value of improved roads and the efficiency of various types.

2. Giving special advice and assistance, where the problem to be solved necessarily involves a knowledge of community and coöperative administration and of methods for planning and financing a system of better roads. At this stage, since the questions are specific rather than general, the lecturer gives way to the engineer.

3. The third step includes an actual demonstration of construction under government supervision. In fact the Office becomes practically a school in regard to road construction.

4. In the fourth step the educational work of the Office deals with the future in so far as it means maintenance. In other

words, in order that the communities may realize the fullest returns from their investment, the people are shown how to adequately care for their public roads.

Research Work.—Fully as important as its educational work, however, is the research and experimental work of the Office. Reasonable coördination between the investigations conducted in the laboratories and in the field is constantly sought, and the laboratories have been specially equipped to further this object.

In working out such of these problems as concern the construction and maintenance of roads, Congress has made a special appropriation for field experiments, and during the past four years test roads have been constructed in the vicinity of Washington. These roads demonstrate the use, according to various methods, of a large number of materials, including oils, asphalts, tars, concrete, brick, crushed stone, and gravel. The results of these field experiments are carefully recorded and a progress report issued annually. Every material which is used in the field experiments is carefully tested, analyzed, and studied in the laboratories so that the fullest correlation is obtained.

Organization to November 1.—In order to render its work most effective, the Office was organized before November 1, 1916, into nine divisions, one of which dealt entirely with the administrative work of the Office. The other eight divisions were as follows:

Division of Road Construction.—Among projects within the province of this division may be mentioned the following:

1. Object lesson roads, which are built for the purpose of teaching local road officials the proper methods of road construction. All materials, labor, and teams are supplied locally, while the Office of Public Roads and Rural Engineering furnishes the services of an engineer.

2. The county model system project, which involves the assignment of an engineer to a county to make all necessary preliminary investigations for the purpose of devising a plan for the administration, construction, and maintenance of a county system of highways.

3. Bridge and culvert work, which consists of the preparation of typical or standard designs, which will be furnished where suitable, upon application from any particular locality. Special designs are prepared for localities where typical designs can not be used. Occasionally designs prepared by bridge companies are checked and reviewed for local officials. In addition, inspections of bridges are made in conjunction with local officials and advice given as to the kind of bridges and culverts best suited for local use.

4. The superintendence of county roads. This involves the assignment of an engineer to superintend the road work of the

county requesting this aid. The engineer assigned makes a thorough study of the county road conditions, with recommendations for improved methods of administration, construction, and maintenance by the properly authorized road officials.

5. The road survey project contemplates extending aid to local communities by providing engineering assistance for making surveys.

6. The post roads project. The Post Office appropriation act of August 24, 1912, appropriated $500,000 for improving, under the direction of the Secretary of Agriculture, such roads as might be jointly selected by the Postmaster-General and the Secretary of Agriculture. After the roads were selected the Secretary of Agriculture placed them under the immediate supervision of the Office of Public Roads and Rural Engineering. The work under this project comprises sections of seventeen post roads located in thirteen States.

7. Field experiments in road construction are conducted with a view to ascertaining the relative merits of various road materials in actual service so that the public may benefit by the knowledge thus obtained.

8. Under the project of inspection and advice an engineer is assigned to a locality for the purpose of making a thorough study of all the road-building conditions, which involve materials, methods of construction and maintenance, traffic requirements, and systems of finance and management. He then advises with local officials as to the kind or character of improvements which should be adopted. Special advice is also given concerning isolated problems that frequently exist in connection with the road work of particular localities.

This division is a part of the Engineering Branch in the new organization.

Division of Road Maintenance.—Conservation of the enormous expenditure of public funds in road construction has become so important and the failure of local officials to provide properly for the necessary road maintenance is so general that there has been a great demand on the Office for assistance in this direction. Consequently a Division of Road Maintenance was created on February 16, 1914. This work became a section of the Engineering Branch of the Office on November 1, 1916.

This section aims to become a clearing house for information regarding the details of maintenance work, its cost, methods, and results. To this end studies are being made in States having well organized highway commissions and in selected counties where funds are sufficient to finance an advanced and efficient highway system.

To give a practical demonstration of maintenance in counties having improved roads of the commoner types, such as earth, sand-clay, and gravel, organized maintenance is being conducted along about 876 miles of a through route from Washington, D. C., to Atlanta, Ga. Engineers furnished by the Office for this work make frequent inspections of the different sections now under maintenance by the patrol or gang system, and give directions for conducting the work. The various counties coöperating in this work provide the necessary funds, except for engineers' salaries and expenses. At the request of the State Highway Commission of North Carolina a similar arrangement has been made for the maintenance of 338 miles of the Central Highway.

Certain of the post roads improved under supervision of this Office are being used, when completed, to secure maintenance cost data representative of the locality. The work is being conducted in coöperation with the States.

If the greatest benefit is to be derived from the experimental road work conducted by the Office, it is essential to insure the continuous maintenance of these roads, and to obtain very accurate cost data and traffic records. This work is therefore being conducted by the Office of Public Roads as a major project. So far, very valuable and original results have been secured and it is expected that the final conclusions will establish the comparative economy of several important types of road with reference to the traffic handled.

Division of National Park and Forest Roads.—This division was created on February 16, 1914. It had charge of certain road work done in the National parks, in coöperation with the Department of the Interior, and of road work done in some of the national forests, in coöperation with the Forest Service of the Department of Agriculture. Congress has provided that 10 per cent of the receipts of the Forest Service shall be expended in constructing roads and trails within the National forests, and that $1,000,000 annually shall be furnished by the federal government for 10 years for similar work. Since November 1, 1916, this work has been under the Engineering Branch of the Office.

Division of Road Economics.—The work of this division comprised general statistical and research investigations, embodying the collection of data to show national progress in road construction and maintenance, including pertinent laws, appropriations, costs, mileage, dimensions, and types.

Investigations begun in 1910 to determine as accurately as possible the economic results of road improvement on the prosperity and development of the country, have been completed and the results are now in course of publication. Studies are under way to obtain comprehensive insight into the methods of management, construction, and maintenance of roads under local control, and also into the organization, methods of operation, and results accomplished by the various State highway departments. An exhaustive study of the employment of convict labor in road work was completed in 1915 and later the conclusions drawn from this study were given a practical test in an experimental camp in Fulton County, Georgia. In addition to the foregoing economic investigations, economic studies are made along the post roads constructed in coöperation with the Post Office Department, in order to obtain the information called for in the appropriation act which caused their construction. A traffic census is taken at regular intervals on the post roads and on the experimental roads.

This division also had general charge of the lecture work of the Office. Lecturers are only assigned upon request and then only when assured that the meeting has been properly advertised and that the attendance will justify the expense. Closely related to this lecture work is that of road model exhibits which are displayed at various expositions, road conventions, and similar meetings. All editorial and photographic work, together with the library, which comprises approximately 9000 volumes, was also under this division.

The division is now a section of the Management and Economics Branch in the new organization.

Division of Road Material Tests and Research.—The work of this division embraced the following projects:

1. Chemical and physical examination of all types of road materials.
2. Microscopic examination and classification of all rocks, gravels, sands, clays, etc., which are of interest in road construction and maintenance.
3. Standardization of methods of testing bituminous and non-bituminous road materials.
4. Researches into the occurrence, manufacture, and properties of dust preventives and road binders.
5. Investigations of non-bituminous road materials.
6. Inspection and advice.

Under these projects numerous experiments are conducted in coöperation with other divisions of the Office, with a view to correlating laboratory tests with service results.

Samples of rock, gravel, sand, and clay are tested free of charge for any citizen of the United States, provided they are submitted strictly in accordance with printed instructions which are furnished upon request and provided the tests will not only prove of value in perfecting the records of the Office with regard to local deposits but will aid in the dissemination of information of particular value to highway engineers.

In certain instances samples of bituminous materials are tested free of charge, when by so doing information may be secured to further the Office in its efforts to coördinate laboratory tests with service results and when such information will aid it in the preparation of specifications for materials of this character. Tests are not made for municipalities.

This division is now a section of the Engineering Branch. The remaining divisions of the Office were not concerned with road work.

Organization Since November 1.—On November 1, 1916, the organization was changed in order to provide for administering the Federal aid road act as well as the work of the eight divisions of the earlier organization. Under the new organization there are two branches instead of eight divisions.

The engineering branch, in charge of a chief engineer, comprises five sections, (1) highway construction and maintenance, (2) road material tests and research, (3) irrigation, (4) drainage, and (5) rural engineering. For administrative purposes, district engineering offices have been established in ten cities, each in charge of a district engineer reporting to the chief engineer. These districts are:

1. Washington, Oregon and Idaho. Headquarters, Portland.
2. California, Nevada, Arizona and New Mexico. Headquarters, Berkeley.
3. Montana, Wyoming, Utah and Colorado. Headquarters, Denver.
4. North Dakota, South Dakota, Minnesota and Wisconsin. Headquarters, Minneapolis.
5. Nebraska, Iowa, Kansas and Missouri. Headquarters, Omaha.
6. Texas, Oklahoma, Arkansas and Louisiana. Headquarters, Forth Worth.
7. Michigan, Illinois, Indiana and Kentucky. Headquarters, South Chicago.
8. Tennessee, Mississippi, Alabama, Georgia, South Carolina and Florida. Headquarters, Montgomery.
9. New England, New York, New Jersey and Delaware. Headquarters, Troy.
10. Ohio, Pennsylvania, Maryland, West Virginia and North Carolina. Headquarters, Washington.

The management and economics branch is under the chief of management and comprises two sections, (1) management, exclusive of the engineering activities of the office, and (2) engineering economics.

Progress Report

During 1916, in addition to organizing the staff for the Federal Aid road work, 5¾ miles of experimental roads were built in Alexandria County, Va., 8 post roads were completed, recommendations for road improvements were made to 32 counties, 113 local road problems were investigated, 31 sets of bridge plans were prepared and 33 investigations of bridge conditions were made. The total area of roads constructed under the supervision of the Office during the year was 4,942,762 square yards. The length of road under maintenance supervised by the Office was over 1275 miles. In the national parks and forests 70 miles of road were completed.

The laboratories made routine chemical examinations of 338 samples of bituminous materials, 115 metal samples, and 21 samples of rock, sand, cement and other materials. Routine physical tests were made of 577 rock and slag samples, 160 gravel, 155 sand, clay and soil; 31 cement and concrete and 56 miscellaneous materials. The microscopic laboratory examined and classified 574 samples of rock and slag, 295 of gravel, sand and clay, and 14 of miscellaneous materials.

The research work was along the following lines: Effect of exposure on tar products, bituminous earth roads, effect of various solvents on extracted bitumen, penetration tests of asphalt, binding value of different bitumens with different rocks, bituminous materials for top soil roads, thickness of bituminous films on aggregates, the viscosity test of fluid bitumens, the float test of heavy refined tars, the effect of colloids on bituminous material, the effect of oils in oil-cement concrete, the effect of the proportions of sand and cement on the toughness of cement mortars, the relation between the physical properties and service results of road-building gravel, waterproofing silos with oil-cement concrete, effect of freezing and thawing on argillaceous rocks, relative effect of mortar and sand cushions for brick pavements, relation between the tensile strength of mortars and the mechanical analysis of sand, the wear of concrete roads, effect of character of aggregates and time of mixing on strength of concrete and the distribution of pressure through earth. A method of incorporating asphalt with earth without preheating the latter has been developed and the material is being tested on a section of experimental road. An experimental plant for refining petroleum and tar products has been constructed and will be used to determine what effect variations in refining methods have on the physical and chemical characteristics of oils and tars.

Funds

The expenditures of the Office of Public Roads and Rural Engineering for the year ending June 30, 1916, were reported by the Secretary of Agriculture as follows: Administration, $39,268.64; road management investigations, $52,352.79; road building and maintenance investigations, $151,419.95; road material investigations, $41,134.63; field experiments, $48,572; farm irrigation investigations, $110,822.89; farm drainage investigations, $101,079.77; investigations in rural engineering, $13,060.20; improvement of post roads, $162,920.71; total, $720,631.58.

Various liabilities had been incurred, bringing the total expenditures and liabilities to $745,171.80, within $37,285.39 of the total available funds.

For the current fiscal year there was an unexpended balance of $34,116.27 for the construction of improvements on rural post routes, an appropriation of $599,200 by Congress, and the funds available under the federal aid road act. The house committee on agriculture requested in December, 1916, an appropriation of $702,100 for the year ending June 30, 1918.

Personnel

Director, Logan Waller Page; chief engineer, P. St. J. Wilson; chief of management, J. E. Pennybacker; general inspectors, T. Warren Allen and E. W. James; chief of road materials tests and research, Prevost Hubbard; chief of irrigation, Samuel Fortier; chief of drainage, S. H. McCrory; chief of rural engineering, E. B. McCormick; district engineers, (1) L. I. Hewes, (2) C. H. Sweetser, (3) J. A. Whittaker, (4) E. O. Hathaway, (5) J. C. Wonders, (6) J. D. Fauntleroy, (7) J. T. Voshell, (8) J. T. Bullen, (9) G. H. Miller, (10) H. K. Bishop.

STATE HIGHWAY DEPARTMENT LEGISLATION[1]

The following notes are intended merely to indicate subjects which should be considered in laws relating to State highway departments. No attempt has been made to prepare a "model law" for such a department. Other laws are also needed in order that the construction and maintenance of roads not under the State highway department shall be carried on economically and efficiently.

It is vitally important to keep in mind the distinction between these two classes of laws. If it is not done highway affairs will become confused instead of simplified. For years to come a very large proportion of the roads of the country will remain under local control and the public interest requires that control to be of a high character. It will prove helpful in any adjustment of State road laws to determine broadly first, what roads shall be put under the control of the State highway department; second, how these roads shall be selected; third, how the responsibility for the improvement and maintenance of these roads shall be divided between the State and its subdivisions; and, fourth, the organization and financing of the State highway department to discharge the duties assigned to it. When this is done, the laws relating to the remaining roads of the State should be reviewed to make sure that the new legislation does not effect harmful changes unintentionally.

The highway laws of no two States are alike. The law governing the State highway department of New Hampshire can be printed in less than half a column of a newspaper, while the law governing the highway department of New York will fill many pages of such a paper. Each State must decide for itself what duties shall be assigned to its highway department and the detail with which the law shall prescribe the procedure to be followed by the department in the discharge of its duties. In this connection it is well to keep in mind that if such a department is to be held responsible for results it should not be hampered by restrictions upon the methods it may adopt to obtain such results.

No attempt has been made to discuss legislation relating to the use of convict labor on road work. It is debatable whether such legislation should be taken up under road laws or under those relating to the State and county prison systems.

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[1] Prepared under the direction of R. Walton Moore, Chairman of the Committee on Legislation of the American Highway Association.

The Main Roads of a State

The agricultural and industrial activities in a State lead to much greater use of some roads than others. These main roads must be improved first, in accordance with a basic principle of public finance, to spend taxes so as to give the greatest good to the greatest number of people.

The determination of the main highways of a State should be entrusted to the State highway department, either entirely or in coöperation with county authorities. The State highway department can make a study of the travel on the leading roads and thus ascertain definitely what service they are rendering and what results can be accomplished by their improvement. To do this work most effectively, the department should be authorized to call upon local boards for help in ascertaining the travel on roads, and on county, township and city authorities for information concerning the roads and highway bridges under their charge. Where such authority is not given local authorities sometimes fail to coöperate with the State department. The Ohio law on this subject reads as follows:

> The State highway commissioner or chief highway engineer may call upon the county highway superintendent at any time to furnish a map or maps of the county showing distinctly the location of any rivers, railroads, streams, township lines, cities, villages, public highways and deposits of road material, together with any other information that may be required by said commissioner or engineer. . . . . The county highway superintendent shall have the right to call upon the township trustees or township highway superintendents to furnish any part of the information called for by the preceding sections, and such officials when so called upon to furnish such information shall be paid their usual per diem in the regular manner for the time employed in furnishing the same.

The State highway department should also be authorized to make all necessary surveys to secure such information, for local authorities are frequently unable to furnish it. If the department restricts its inquiry to main roads, it is thereby relieved from the consideration of roads of local interest except as their problems are submitted by local authorities for its advice.

The experience in Pennsylvania, where the main roads are designated by law, indicates that a legislature will relieve itself of needless trouble and the taxpayers of needless waste of money by entrusting the selection of the main roads to the State highway department. The Pennsylvania legislature designated 10,200 miles of its roads as State highways. Only a small part of this mileage has been improved, and the roads selected do not form a satisfactory system. Moreover the length of the roads is altogether too great for the money available for their improvement. The result is stated by Chief Engineer William D. Uhler of the State highway department as follows:

> During 1915 the department spent about $4,500,000 in maintaining this mileage and during 1916 it will spend about $3,000,000, making a total of $7,500,000 spent on the roads in two years, with nothing of any great moment in the way of permanent improvement to show for it. Had it been possible to spend this $7,500,000 in permanent construction, from 500 to 600 miles of highways could have been improved during 1915 and 1916, which added to the 1,880 miles already improved, would have furnished a satisfactory nucleus for the permanent highway system of the State.

In Massachusetts on the other hand, the State highways are designated by the State highway commission upon petition of local authorities, city, town or county. As soon as a highway has been thus designated it passes under the complete jurisdiction of the State highway commission, which has control of its construction and maintenance, the location of poles, conduits and tracks on the right-of-way, and the planting and removal of trees and other vegetation on the roadsides.

In Illinois the highways receiving State aid are selected by the county officials, subject to revision by the State highway commission. "The highways to be designated by the county boards shall be as nearly as possible those highways connecting the principal cities and trading points in each county with each other and also with the principal cities and trading points in other counties."

In Connecticut, the State highway commissioner has the power to lay out and improve any trunk road in any town, and to select highways to be improved by the towns with State aid.

In Ohio some of the State highways are designated by statute and the remainder are designated by the State highway commissioner.

The general opinion of highway officials of wide experience is that the main roads of a State cannot be improved and maintained satisfactorily except under the charge of a State highway department. It is undoubtedly true that the most direct way of accomplishing this object is the best way; all the engineering work should be done by the department, all contracts let by it, and all force account work done by its employes. But in some States this is impracticable on account of a constitutional prohibition against the State undertaking works of public improvement, and in other States public opinion has not yet appreciated fully the economic advantages of complete State control over what are essentially State roads. In such a case it is necessary for the State highway department to work through county officials to secure a system of main roads. This is the case in North Carolina, for instance, where the highway law of 1915 reads as follows:

> Upon the written request of the road officials of any county desiring to avail themselves of the services of the highway engineer on the terms of this act, for advice in regard to the improvement of any bridge, road, roads or section thereof, the (State) highway engineer shall survey or have surveyed such bridge, road, roads or sections of roads, and shall prepare or have prepared, such maps, profiles, plans and specifications as are necessary in his judgment to determine the cost of the proper improvement of such bridge, road, roads or sections of road; and these, together with the estimated cost, shall be presented to the board of county commissioners or other officials in authority, who made the request for such information, at their next regular meeting held after the completion of such surveys and estimates. If such bridge, road, roads or section of road shall thereafter be built by the county officials, it shall be constructed according to the plans and specifications as furnished by the highway engineer. In the event that the construction work on any such bridge, road, roads or section of road is not started within twelve months after the highway engineer makes his report to the county officials, the county officials shall, and are hereby directed to, reimburse the State highway commission for the expense incurred by its office in obtaining the information furnished the county officials. Should, however, the construction be taken up at a later date, the highway engineer, when he takes charge of the actual construction, shall return said amount to the county officials. The highway engineer, or his duly authorized assistants, shall have entire charge of the location, construction and maintenance of all roads, bridges, etc., constructed under this section. The State highway engineer shall keep an accurate record of all costs and expenditures of his office. He shall supply technical information regarding roads to any citizen or officer in the State, and shall, from time to time, publish for public use such information as will be generally useful for road improvements. Such publications and his biennial report[1] to the legislature shall be printed at the expense of the State, as other public documents.

No haphazard, disjointed method of improving main roads, without a definite plan by which the work of today will eventually become a part of a complete system of intercounty highways, will prove satisfactory. Secretary Houston of the United States Department of Agriculture laid stress on one important aspect of this in the following statement in the *Review of Reviews* for September, 1916:

> In accepting the terms of the [federal aid road] act the State, as a matter of course, pledges its faith to the five-year program. This is important because it makes possible the arrangement of a comprehensive scheme of road building. Obviously the expenditure of the entire amount of money

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[1] An officer of a commission should preferably report to the commission rather than to the legislature.

contemplated by the act should be planned at the outset as far as possible and road systems and projects conceived accordingly. This does not bind the State legislature to make an appropriation at the first session for the five-year period. This would be prevented by the constitutions of many States; but it does involve a pledge of the State's faith to continue the appropriations according to the terms of the act.

Where main roads are built by the State highway department the latter must be given authority to acquire necessary rights-of-way by purchase or condemnation proceedings and to abandon old rights-of-way. Where State funds are contributed to work done by local officials, the State department should be authorized to withhold State aid until the local authorities have provided satisfactory rights-of-way.

Organization and Duties of State Highway Departments

In some States the department is managed by a single commissioner and in others by a board of commissioners. The advantage of concentrating authority in a single commissioner is that a good administrator can accomplish more than a mediocre board, and it may not be so difficult to obtain a good administrator as it is to obtain a harmonious, energetic and capable board. On the other hand, a board composed in part of State officials and in part of civilians, including professors of engineering in State colleges, is perhaps more likely to be free from individual predilection, in closer touch with public opinion in different parts of the State, and apt to take a broad view of problems because relieved of direct responsibility for details. Excellent work is being done under both systems of administration. The law should, of course, state the terms of office of the commissioners and the method of their appointment.

The following States have highway commissions of several members or some equivalent body; Alabama, Arizona, Arkansas, California, Colorado, Florida, Idaho, Illinois, Iowa, Louisiana, Maine, Maryland, Massachusetts, Minnesota, Mississippi, Montana, New Jersey, New Mexico, North Carolina, North Dakota, Oregon, Rhode Island, South Dakota, Tennessee, Utah, Virginia, West Virginia and Wisconsin. In many of these States, as Louisiana, New Jersey and Virginia, the duties of the commission are little more than advisory, and the State highway commissioner has practically complete control of the State road affairs.

In a number of States the highway commission consists of three or more State officials. In other States, the board consists of a few State officials acting with professors of engineering in State schools and occasionally with two or three private citizens appointed by the governor. In other States, all the commissioners are private citizens. In many States the commissioners draw no pay, but are allowed their actual expenses, but in other cases they are paid. The North Carolina highway law of 1915 contains the following clause typical of recent legislation:

> The State highway commission shall consist of the governor, three citizens of the State of North Carolina to be appointed by the governor, one from the eastern, one from the central, and one from the western portion of the State, one of whom shall be a member of the minority political party, the State geologist, a professor of civil engineering of the University of North Carolina and a professor of the North Carolina Agricultural and Mechanical College, said professors to be designated by the governor. The members of the commission shall be appointed and serve for four years, and until their successors are appointed; the members of the commission shall, when employed in any manner required of them under this act, receive their actual expenses. The governor shall fill all vacancies in the commission caused by death or otherwise, and he shall have the power to remove any member for due cause.

The following States have a single highway commissioner: Connecticut, Kentucky, Michigan, Missouri, New Hampshire, New York, Ohio, Oklahoma, Pennsylvania, Vermont and Washington.

Whether a commission of several members or a single commissioner is placed in charge of the State highway department, the duties to be performed should be stated comprehensively and clearly in the law. The Ohio statute, for example, reads as follows:

> The State highway commissioner shall have general supervision of the construction, improvement, maintenance and repair of all inter-county highways and main market roads, and the bridges and culverts thereon. He shall aid the county commissioners in establishing, creating and preparing suitable systems of drainage for highways, and advise with them as to the construction, improvement, maintenance and repair of highways; and he shall approve the design, construction, maintenance and repair of all bridges, including superstructure and substructure, and culverts or other improvements on inter-county or main market roads; and in the case of bridges and culverts on other roads, when the estimated cost thereof exceeds $10,000, the plans therefor shall be submitted to and approved by him, before contracts are let therefor. He shall cause plans, specifications and estimates to be prepared for the construction, maintenance or repair of bridges and culverts when so requested by the authorities having charge thereof, and he shall cause to be made surveys, plats, profiles, specifications and estimates for improvements whether upon State, county or township roads. He shall make inquiry in regard to systems of road and bridge construction and maintenance whenever he may deem it advisable, and conduct investigations and experiments with reference thereto, and make all examinations, in his opinion, advisable, as to materials for road construction or improvement.

The statutory duties of a State highway department vary widely in the different States, but may be summarized as follows:

Miscellaneous Duties

a. Lease offices.

b. Purchase furniture and office and engineering supplies.

c. Engage assistants, employ skilled and unskilled labor, and utilize convicts and prisoners.

d. Maintain facilities for testing materials used in road and bridge construction, and investigate sources and properties of such materials.

e. Issue permits for occupation of State and State-aid roads by tracks, pole lines, conduits and other structures.

f. Collect automobile fees and issue regulations governing the use of vehicles on public roads.

g. Issue regulations for use of State and State-aid roads by traction engines, motor omnibuses and trucks.

h. Institute suitable legal proceedings to stop violations of the highway and bridge statutes.

i. Conduct investigations and collect statistics of traffic.[1]

j. Keep detailed records of the receipt and expenditure of all State road and highway bridge funds.

k. Give names to through routes and mark them or permit them to be marked by colors and signs.

l. Acquire toll roads, bridges and ferries.

Educational Duties

a. Collect information relating to roads and highway bridges in the State.

b. Investigate the suitability of different types of road and bridge construction for use in the State.

c. Hold public meetings to explain the desirability of road and bridge improvements.

d. Hold meetings with county and township road officials to discuss the improvement and maintenance of roads and bridges.

e. Publish annual reports of department's work and bulletins on subjects relating to the construction and maintenance of roads and bridges.

f. Notify local officials of road and bridge work which is being done in a wasteful manner, and if the wasteful methods are continued report them to the governor.

g. Prepare standard plans and specifications for roads and bridges.

State Road Duties

a. Determine the main roads of the State and prepare maps of them.

b Designate the order in which main roads shall be improved with State funds.

c. Acquire rights-of-way by contract or condemnation proceedings.

d. Prepare plans and specifications for roads and bridges built by the State and supervise their construction.

e. Make contracts for State road and bridge improvements and maintenance.

f. Carry on construction and maintenance of State roads and bridges with day labor, both free and convict.

g. Buy or hire machinery, tools, materials, teams and supplies needed in carrying on the work of the department.

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[1] Legislation is contemplated in some States forbidding the construction of gravel roads when the traffic exceeds certain limits.

Coöperative Duties

a. Prepare or aid in preparing plans for road and bridge improvements by local officials.

b. Supervise or assist in supervising construction and maintenance of roads under local officials.

c. Apportion among the counties or other subdivisions State funds for coöperative road and bridge work.

d. Act with local authorities in designating road and bridge work on which State funds shall be spent.

e. Approve contracts for road and bridge work made by local officials.

f. Hold competitive examinations for positions of county highway superintendents or engineers to furnish lists of capable men from which counties must select such officials.

g. Approve plans for road and bridge improvements submitted by local officials.

h. Determine when State-aid roads are improperly maintained, in case the law prohibits further State aid to counties where State-aid roads are not kept in satisfactory condition by the counties.

i. Inspect annually all bridges exceeding 30 feet in length and advise local authorities of their condition.

j. Prepare and distribute directions and forms for accounting for local road funds and recording all official actions of local road authorities

How many of these duties shall be assigned to the highway department of any State will depend upon the extent to which the legislature desires the department to devote itself to educational work, the construction of roads and bridges by State funds solely, or the assistance of local authorities in their work of this nature.

Engineering Work

No State highway department can be of more than nominal service without a capable engineering bureau. This is as true where the actual construction of roads is carried on by counties and townships as where construction is also carried on by the State itself. The duties of the engineering bureau will depend very largely upon the entire body of State road laws, however, and the statutory provisions governing this branch of State highway departments vary widely.

In some States, the duties and subdivisions of the bureau are defined very elaborately, as in Ohio, whereas in Illinois the law merely provides for a chief State highway engineer and an assistant State highway engineer "who shall be the administrative and technical agents" of the State highway commission, subject to its orders, and also directed to give advice to county, township and road district officials on road and bridge subjects. The other members of the engineering bureau are provided for in a clause authorizing the commission to employ such assistants as are needed to carry on its work. The Iowa law does not even mention an engineering bureau, but merely defines one of the commission's duties to be "to appoint such assistants as are necessary to carry on the work of the commission, define the duties and fix the compensation of each, and terminate at will the terms of employment of all employes, provide for necessary bonds and fix the amount of same." The commission has made the following statement regarding its policy under this law:

> The three commissioners, acting in the nature of a board of directors, have organized a competent, efficient force of engineers, who are carrying out the policies of the commission and doing the detail work imposed upon it by law. All assistants and employes hold office in accordance with the provisions of certain rules adopted by the commission. The commission also determines which of its assistants shall give bonds and fixes the amount of such bonds. By a resolution of the commission, the principles of civil service are applied in the employment of the working force, to the end that the most competent help may be obtained and the greatest efficiency thereby secured.

As a general rule, a department works best when it has authority to organize its staff as it deems best suited to the work, but there should be no question about the importance attributed by the legislature to efficient engineering. For this reason, where one of the commissioners, in case of a board, or the commissioner himself, where the department is headed by an individual, is not required by law to be an engineer, the following clause in substance is desirable in the law governing a State highway department:

> The State highway commission shall appoint a State highway engineer, who shall be a competent civil engineer, experienced and skilled in highway construction. He may appoint, subject to the approval of the commission, such technical assistants as may be necessary for the proper conduct of the engineering work of the commission.

In many States, the actual purpose of the State highway department is essentially regulatory and advisory. It is intended by the legislature to be a preventive of inefficiency on the part of local highway authorities, and this purpose is accomplished by two general classes of statutory requirements, the first governing the class of men placed in charge of road work by local authorities and the second requiring the submission of plans by the local authorities to the State Department or to a competent engineer for approval before work can be undertaken. The following clauses (from the Illinois highway laws) relating to local road work illustrate this tendency of recent legislation:

> In each and every county of the State there shall be a county superintendent of highways to be appointed in the manner following:
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> Within ninety days after this act shall become effective, the county board of each county shall submit to the State highway commission a list of from

three to five persons, residents of the county, considered desirable candidates for the office of county superintendent of highways. The State commission shall thereupon determine by competitive examination from among the names submitted the person or persons best fitted for said office, and shall thereupon certify the same to the county board submitting such list, who shall then make an order appointing from the number found eligible one such person superintendent of highways for such county. Provided, however, that if on the list submitted there is found no person qualified for the position the county board shall in like manner submit a further list, and if on this second list no one is found qualified the county board may[1] employ some person other than a resident of the county and who has passed satisfactorily the examination presented by the State highway commission.

No part of any moneys appropriated by the State for the building and maintaining of State-aid roads shall be apportioned to any county until such county superintendent of highways shall have been appointed.

The highway commissioners of each town or road district shall have power and it shall be their duty . . . . to direct the construction and repair of roads and bridges within the town or district, to let contracts, employ labor and purchase materials and machinery therefor, subject to the limitations herein provided: Provided, however, that no contract shall be let for the construction or repair of any road or bridge or part thereof in excess of the amount of $200.00, nor shall any machinery or other appliances to be used in road construction in excess of such amount be purchased without the approval of the county superintendent of highways.

Whenever it shall be voted to construct gravel, rock macadam or other hard roads, or to improve dirt or earth roads and to oil-treat the same, or to oil-treat the roads in any township or district, it shall be the duty of the county superintendent of highways of the county in which said township so voting is located to at once survey (or cause to be surveyed) the route of the road thus to be improved and to prepare suitable maps, plans, specifications and estimates of the cost of the proposed improvement.

Upon the completion of the contract the commissioners and the county superintendent of highways shall make a thorough and complete examination and estimate of said work, and, if found in accordance with the specifications of the contract, the commissioners, upon the certificate of the county superintendent of highways, shall issue his order on the treasurer for the full amount due the contractor.

The Illinois plan is, therefore, to have practically all the road construction not done under the immediate supervision of the State highway commission, performed under men whose fitness it has determined by competitive examinations. The only important work over which the State commission or the county superintendents of highways have no regulatory authority is the dragging of the earth roads, and the opinion seems to be growing that it is desirable to direct the State highway department to notify local authorities when such local road work is being performed inefficiently.

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[1] It would perhaps be better to use "shall" instead of "may," so as to make the provision mandatory. The State highway commissioner of Virginia, G. P. Coleman, is satisfied that county boards in some States will not go outside their counties to secure competent superintendents unless compelled to do so.

Engineering Coöperation With Local Highway Officials

There is very little uniformity in legislation governing the coöperation of State highway departments with local highway officials. This is doubtless due to the tendency of law-makers to add the State highway department legislation to the existing road statutes. Such statutes vary greatly in the different States and consequently the method of dividing authority between State and local officials has varied. No workable law creating a State highway department can be drafted except with a full knowledge of the existing statutes governing every feature of highway administration in the State. With such knowledge, it is possible to repeal and amend existing laws at the same time new laws are made; without such knowledge there is every probability of unbalanced and even conflicting laws. For this reason, a legislative committee instructed to draft laws for the organization or reorganization of a State highway department may also be advantageously empowered to report on amendments to existing laws relating to local roads. In many States such laws are capable of great simplification and improvement, owing to their being the result of occasional legislation during a long period of time.

There are two main classes of coöperative work, one in which the expense is shared by the State and the local authority, and the other in which the expense is borne wholly by the local authority.

When the expense is shared by the State and the local authority, it is the tendency of recent legislation to require the plans, specifications and estimates to be prepared by the State highway department, which advertises for bids, lets the contract and supervises the construction. Sometimes the law specifies part or all of the procedure in such work and sometimes it leaves the State highway department free to act as it deems best.

Where the intent is to have the expense of construction shared by the State and county, it is customary to provide in the law that the county must provide its share of the money before the State appropriation is paid.[1]

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[1] Frank F. Rogers, State Highway Commissioner of Michigan, advocates incorporating in the law provisions which will insure the maintenance of roads constructed with State aid. The Michigan law provides for the payment to the counties by the State for the maintenance of such roads an amount equal to 2 per cent. of the State aid for construction. This small payment does not lead to proper maintenance in all cases and often it is necessary to withhold State aid for further construction in order to obtain proper maintenance.

When the whole expense is borne by the local authority, some laws require the State department to make the plans, specifications and estimates for main road improvements if requested to do so, but also permit the local authorities to prepare these plans and specifications if they prefer. In the latter case, the local authorities are sometimes required to have the plans and specifications for work costing more than a specified amount approved by the State highway department or by an engineer whose qualifications are satisfactory to the department, but generally the law is silent and the local authorities can do as they please. Inasmuch, however, as the expenditure for local roads is often heavy, it is decidedly to the advantage of the taxpayers to have all important local work of this sort subject to the approval of the State department[1] or of an engineer approved by the department, as in Illinois (see page 46).

In Iowa, where the State makes no financial contribution toward road building, the statutes place numerous responsibilities in road building and maintenance upon county and township officials, and the State highway commission is authorized by the following provision of the law to see that these duties are properly performed.

> The State highway commission shall have general supervision of the various county and township officers named in this act in the performance of the duties here enjoined, and shall have full power and authority to enforce the provisions of this act.

Each Iowa county is required to have a county engineer, who may be removed for incompetency by the State highway commission as well as by the county supervisors. The county supervisors select a part of the roads as county roads and the remainder are termed township roads. The county road system must have the approval of the State highway commission. The county engineer plans the improvements on the county road system, but no work can be done until the plans have been approved by the State highway commission. The approved plans must be recorded "at length in a county road book," by the county auditor. The township roads are under the township trustees, who are required to perform numerous duties in connection with such roads, and to carry out permanent improvements only under the plans and supervision of the county engineer, whose services for such work must be supplied without charge to the township officials by the county.

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[1] "Emphasis should be given to the importance of legislation requiring counties to have specifications for road machinery, culverts and bridges approved by the State highway departments before purchases are made. Many Southern counties have wasted thousands of dollars by the ignorant purchases of such, and while it might not be wise to make the State highway department purchasing agents for the counties, the adoption of intelligently approved specifications would not be an invasion of county rights." W. S. Keller, Alabama State Highway Engineer.

A weak feature of the road laws of many States is the indefinite manner in which responsibility for bridges and culverts is stated. A considerable proportion of the highway bridges of the country are unsafe. It is therefore recommended that any new legislation relating to a State highway department shall contain the following or equivalent provisions:

> All bridges on roads built or maintained with the aid of State funds shall be inspected annually by the State highway department. If any such bridge is found at any time to be unsafe, the State highway department shall either close the bridge to travel and post notices instructing travelers how to make a detour around the bridge, or it shall post notices warning travelers of the dangerous condition of the bridge and requiring them to exercise due caution in crossing it. If any such bridge is found to be in a dangerous condition, the State highway department shall at once notify the county, township or district owning it and prepare plans for the restoration of the bridge to a safe condition and proceed to have the work done by contract or day labor as the department shall consider best. The cost of this work shall be deducted from the State funds allotted to the county, township or district, owning the bridge, in case the said county, township or district will not at once assume responsibility for the charges. In case the allotment of State roads funds to the said county, township or district is inadequate to pay the entire cost of such work, the balance shall be met by the treasurer of said county, township or district from any unappropriated funds in his possession or by issung warrants to be paid in full from the proceeds of the next tax levy.
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> All bridges of more than 20 feet span on roads not built or maintained with the aid of State funds shall be inspected annually by the State highway department. If any bridge is found to be unsafe, the department shall at once post notices warning travelers of the condition of the bridge and if the condition of the bridge makes its use hazardous to travelers the department shall immediately take the necessary steps to prevent any use of it until the department has ascertained by inspection that the bridge has been made reasonably safe. As soon as the State highway department determines that a bridge is unsafe it shall immediately notify in writing the county, township or district owning the bridge of this fact and also state the legal responsibilities of the county, township or district to maintain the bridge in a safe condition.
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> The State highway department shall report any failure of counties, townships and districts to maintain their bridges in a safe condition to the attorney general, who shall take such steps as he deems advisable to have the counties, townships and districts make such bridges safe for reasonable use.

A State highway department can render great help to local authorities by preparing plans, specifications and estimates for roads and bridges. On the other hand, the amount of such engineering service which will be demanded in a State where highway improvements are actively conducted will be altogether beyond the resources of any State department. Consequently it is advisable to make the local authorities pay for such services, as is done in North Carolina (page 40), or restrict the services to "giving advice on roads and bridges," or to the preparation of standard plans for bridges and culverts, or to some combination of these duties. If the State highway department itself carries on construction work, its engineering bureau will be busy with many technical and executive affairs, and should not be required to spend much time in coöperative work unless adequate financial provision is made for a staff large enough to perform such duties.

Coöperation With National and State Road Officials

Under the terms of the federal aid road law of 1916, the United States Department of Agriculture is authorized to coöperate with the State highway departments in road-building. It is desirable that the State laws designate in turn the State highway department as the representative of the State in such matters. The 1915 Oklahoma highway laws contain the following clause on this subject, under the section defining the duties of the commissioner of highways:

> *Fifth:* To coöperate with the federal government in all matters pertaining to the improvement of public highways; and all funds provided by congress and appropriated for the improvement of the public highways in this State shall be expended under the supervision of the commissioner of highways.

Coöperative investigations and plans by the highway departments of different States are becoming of marked importance, and the highway law of any State should authorize such coöperation, as well as joint work with the federal department.

Educational Work

In many States, it has been considered desirable to have the State highway department devote a part of its efforts to educational purposes, both to aid the public in appreciating the importance of good road administration and to train the local road officials in the best methods of conducting their work. In some laws, the departments are directed to hold annually a specified number of public meetings for explaining road affairs to taxpayers, and to issue bulletins on road subjects for general distribution. In other laws, this educational work is provided for under a general clause instructing the department to "aid at all times in promoting highway improvement throughout the State."

Recently the educational work of a State department among local highway officials has been provided for by explicit clauses in some road laws. In West Virginia, the department gives annually a special course of instruction in highway engineering and the law requires all county road engineers to attend this course for at least ten days each year. In the 1915 North Carolina road law, this educational work is provided for in the following words:

> The State highway commission shall, upon written request of the county commissioners of any county, call an open meeting to be held at the office of the county commissioners within such county for the purpose of affording instruction relative to matters pertaining to road and bridge construction, maintenance and repair. Such meeting shall be conducted by the State highway engineer or one of his assistants designated for the purpose by the State highway engineer. Upon receipt of the notice of the date of such meeting from the State highway commission the county commissioners shall call such meeting on the date set by the State highway commission, and shall be present themselves and notify the county engineer, the commissioners of each township, and the superintendent of each road district within the county to be present at such meeting in person. Each of the county, township and road district officials above mentioned shall be paid the regular per diem allowance, in the usual manner, for the actual time in attendance at such meetings.

The same end has been reached in other States by requiring the State highway engineer to hold at least one meeting annually in each county to discuss local road affairs, which the local road officials must attend, being paid their usual per diem for such attendance.

Accounting for Road Funds and Recording Official Actions

One of the most unsatisfactory features of local road administration today is the ordinarily defective methods of accounting for local road funds. There is no legal authority given to State highway departments to require the management of local funds, over which the departments have no control, to be accounted for in any manner. On the other hand, part of the waste of local road funds is probably due to defective book-keeping in connection with their collection and payment. Complaints of the troubles thus caused are made by township, county and State road officials alike.[1] The remedy that seems at present most likely to prove effective without causing friction is to direct the

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[1] "Too much emphasis cannot be laid on the importance of requiring the counties or local road units to keep suitable cost records. The determination of the type of road to be built in any locality is often dependent upon the knowledge of the cost of construction and maintenance of a similar type in another location." Frank F. Rogers, State Highway Commissioner of Michigan.

State highway department to prepare and distribute to local authorities directions and blanks for recording such financial transactions. The Illinois highway law meets this need with the following clause among those relating to the duties of the State highway commission:

> Prescribe a system of auditing and accounting for all road and bridge moneys for the use of all highway officials, which system shall be as nearly uniform as practically possible.

The methods of recording official acts and of keeping minutes of meetings is often defective among local road officials, and it is desirable to have such records kept properly. On this account, the State highway department should be specifically authorized to extend aid in such work. This subject, as well as good accounting, can be provided for by some such clause as the following, among the clauses describing the duties of the State highway department.

> Prepare and distribute to local authorities forms for accounting for the receipt and disbursement of road and bridge funds and for recording official actions relating to road and bridge work.

Road Building Materials

The utilization of local road building materials to the fullest extent which is economically advisable is of course desirable. This can only be done when the location and character of such materials is known, and such information is far from complete in many States. For this reason, it is well to give the State Highway Department definite authority to make such investigations and to call on public officials, such as State geological and agricultural specialists, for assistance in obtaining information. The highway law of Arkansas has the following provision:

> The consulting engineer and the State geologist shall make such investigations and reports as the State highway commission may from time to time require. They shall be specially charged with the study of the road materials of the State, their location, relative value, cost and durability and the cost of transporting the same to other parts of the State.

As investigations of sources of road materials must be supplemented by examinations of their quality, the State highway department should be authorized to establish a testing bureau of its own or to use testing facilities already belonging to some other State organization. The Ohio law not only authorizes the State highway commissioner to establish his own apparatus for testing materials but it also contains the following provision:

The apparatus and supplies of the college of agriculture and engineering of the Ohio State University may be used by the State highway commissioner or any of his employes in making investigations concerning the chemical and physical character of road and bridge materials. The college of agriculture and engineering of the Ohio State University, when called upon by the State highway commissioner, shall make investigation and conduct experiments with reference to road building materials or for the purpose of determining any matters connected with road or bridge construction.

Financial Provisions for a State Highway Department

The highway departments of a number of States have been organized under statutes which assign them useful duties, but they are unable to accomplish more than nominal results when only trifling sums are made available for the work. For this reason, in legislating the financial provisions for a State highway department should receive careful consideration.

The salaries of the commissioners are usually stated in the law, with provision for the payment of necessary expenses incurred in the discharge of their official duties. The salary of the chief engineer is sometimes fixed by law. In a few cases, the law requires certain officials to furnish bonds.

The law must provide funds for (a) the general administrative work of the department, (b) its educational work, (c) its coöperative work, and (d) the construction and maintenance work carried on under its sole direction.

It is customary to provide a single fund for the work under classes (a), (b), and (c). Sometimes this single fund also includes the sums for work of class (d), and sometimes such work is done under other funds.

The funds for the work of a State highway department are raised in various ways, including (1) direct appropriations, (2) part of the proceeds of the sales of public lands, (3) automobile fees, (4) taxes, and (5) bond issues. The details will often depend upon other laws relative to the revenues of the State and its subdivisions.

The financial system for the highway department of any State should be determined only after a close scrutiny of the methods already prescribed for raising road funds for expenditure under the direction of local authorities. This will reduce the probability of a conflict of laws, or an inequitable distribution of the burden of road improvements.

In some States, cities pay no contributions toward country roads. The economical advantages of good highways are probably as great to the urban as to the rural population, and it is generally considered proper that taxation for rural roads should apply to the towns and cities as well as the rural sections of the district taxed.

Funds for administrative, educational and coöperative work are usually provided by annual or biennial legislative appropriations, when the State does not itself carry on construction.

The fees from the registration of motor vehicles and the licensing of their operators are generally considered best used in maintaining roads, although they are now employed in a number of States for construction. In some States the fees, less the expense of collecting, are returned to the counties where they are collected to be used there for road purposes. In other States they are expended by the State highway departments for maintenance. In Virginia a recent law directs all such fees to be spent on road maintenance by the counties under the direction of the State highway commissioner, but no county shall receive any part of such fee unless it contributes an equal sum for the same purpose.

In a number of States, money is raised by taxation for a State highway fund, which is apportioned among the counties upon some basis specified in the law. In some cases equal sums are given to each county; in other States part is apportioned on the basis of their assessed valuations and the remainder according to their areas; in other States, part of the fund is apportioned according to the assessed valuations and the remainder as the State highway department deems best for the interests of the State as a whole; in others, the State highway department determines how the entire sum shall be apportioned, without any statutory control over the distribution; in others, the funds are allotted to the local road authorities as awards for the completion of road work satisfactory to the department. In many States, State financial aid is made contingent upon the provision by the county or other local authority of at least an equal sum.

In several recent statutes provision is made for the maintenance of roads constructed under the State aid plan, and in a few cases the State highway department is directed to refuse further financial aid to counties which do not maintain properly the existing State aid roads under their charge.

The Illinois highway law contains the following provision:

> If any county desires, more rapidly than its allotments of State-aid road moneys will permit, to construct a State-aid road along one or more of its highways that have been selected and designated, under the provisions of this act, as State-aid roads, such county is hereby authorized to advance, out of any county funds available from any source, or which may become available from any source, for such purpose, the entire cost of constructing such State-aid roads and to make such improvement at any time. Such county shall, in such case, have the right to use any allotment of money made to it by the State highway commission, to defray one-half the cost of constructing new State-aid roads, in the county, under

the provisions of this act, or to apply the money on the payment of any bonds or other obligations which have been or may be issued by such county, under any law of this State, to meet the cost of construction of any State-aid road or roads constructed by such county at its own expense: Provided, however, that the allotments made by the State shall not be used to cover more than one-half the cost of the construction of such State-aid roads: And provided, also that such State-aid roads shall have been constructed under, and in accordance with, plans, specifications, estimates of cost and contracts approved by the State highway commission and which roads shall have been found, upon inspection of the State highway engineer, to have been completed as provided for in said contracts.

ALABAMA

State Aid Legislation

The State highway commission consists of a professor of civil engineering in the Alabama Polytechnic Institute, the State geologist, and three civilians appointed by the governor, who hold office for four years. The commission deals with matters of general policy and acts for the highway department in making recommendations to the governor and in all dealings which the highway department may have with the governor and the legislature.

A State highway engineer is chosen by the commission and holds office at their pleasure and he is required to be a competent engineer experienced in road building. He is required to make a general highway plan of the State, collect information, determine the character and supervise the construction of roads built through the aid of the State, and he is further required to prepare a map showing such of the main highways in the State as in his judgment are of sufficient importance to be designated as State roads and which should be improved and maintained at the cost of the State in coöperation with the counties. State funds can be used only on roads designated as State trunk roads.

A cash appropriation is made and apportioned equally to all the counties in the State on condition that the counties provide an equal amount. Any county desiring such aid shall make a written application to the State highway commission and power is given the State highway engineer to approve or disapprove this application. The preparation of plans and specifications and the actual construction of the roads selected are under the direct control of the State highway engineer, who is also authorized to thereafter require that such roads be kept in proper repair, and if the county fails to carry out the recommendations of the State highway engineer in the maintenance of such road, the State highway commission may prescribe rules under which the work may be done by the State and the expense paid by the county, or if the county defaults, the payment shall be made out of any money due the county from the State aid fund.

The appropriation for the last fiscal year was $154,000 less the expense of operating the State highway department, or an average of $2000 per county.

Local Road Legislation

Jurisdiction over local roads vests in an elected board of county commissioners consisting of the probate judge and four others, but, by special statute, boards of revenue or like boards may be created to take the place of boards of county commissioners. A supervisor of roads for an entire county may be appointed by the board. Road taxes may be worked out in counties having less than $100,000,000 assessed valuation. The board of a county divides it into road precincts and appoints a road overseer for each precinct.

Local Bond Issue Legislation

The court of county commissioners and board of revenue of any county may order an election on the question of issuing bonds of the county for building roads or to pay debts created for the building of roads. After an election is held, another such election shall not be held within one year. A majority vote is necessary to carry. The amount of bonds shall not exceed 3½ per cent of the assessed value of property and shall bear not to exceed 5 per cent interest, shall be sold for not less than par value, and shall run for such time as may be fixed by the court of county commissioners and board of revenue. No specific provision is made by law for retiring such bonds, and this matter presumably is left to the discretion of the court of county commissioners and board of revenue.

Convict Labor Laws

The convicts of any county or municipality may be worked upon the public roads, bridges or ferries of the county under the direction of the court of county commissioners, or they may be hired to other counties. State convicts may be hired by a county.

Highway Officials

State Highway Commission.—Robert E. Spragins, chairman; John Craft, J. B. Rylance, Dr. Eugene A. Smith, State geologist, University of Alabama; G. N. Mitcham, professor of engineering, Alabama Polytechnic Institute; W. S. Keller, State highway engineer, Montgomery; J. B. Converse, assistant State highway engineer.

Automobile Registration

License fees for private cars: Gasoline, under 25 h.p., $7.50; 25–30 h.p., $12.50; 30–40 h.p., $17.50; 40 h.p. or more, $20. Electric, $12.50; Steam, $15; Motor cycles, $3; motor cycles with side car, $5.

License fees for commercial cars: under 40 h.p., same as for private cars; 40 h.p. or more, $25.

License fees for motor buses: 5 passengers or less, $25; 5–10 passengers, $40; 10 or more passengers, $60, except when running between places 10 miles or more apart, when the fee is $40.

The licenses are issued by the probate judge of each county, who sends 40 per cent to the treasurer of the city or town where the licensee resides, 40 per cent to the county treasurer and 17½ per cent to the State treasurer, and retains 2½ per cent as commission.

Progress Report

While most of the country was experiencing exceptional prosperity, the boll weevil and a July flood caused serious distress in Alabama in 1916. Road construction was carried on as extensively as practicable in order to assist farmers whose crops were destroyed, as well as for the usual objects. The state and counties combined in spending $175,792 on roads and $12,963 on bridges. Over 1000 miles of county road construction was carried on, but exact figures are not yet available. The joint state and county work comprised 37.9 miles of sand-clay roads, 34.35 miles of earth roads, 6.5 miles of chert roads, 20.95 miles of gravel roads, 13 miles of railroad converted into slag and cinder roads, 3.35 miles of gravel road with bituminous binder, 220 feet of concrete bridges and 132 feet of steel bridges.

Road Funds

The funds to be spent under the state department include a state appropriation of $269,000; a county appropriation of $269,000 to secure the state appropriation, federal appropriations of $104,148.90 and $208,297.80, and a county appropriation of $312,446.70 to secure the federal appropriations.

The federal-aid system as planned embraces 2727 miles, of which 1851 miles have already been built.

[Approved by W. S. KELLER, State Highway Engineer.]

ALASKA

Laws Governing Road Work

Road improvements are conducted under an act of Congress of 1905, amended in 1906. It directs all returns from liquor, occupation or trade licenses obtained outside incorporated towns to be placed to the credit of an "Alaska fund," of which at least 65 per cent shall be spent in Alaska for roads, trails and bridges. A board of road commissioners composed of army officers has charge of the location, construction and maintenance of roads and trails, under the restriction that "no such road or trail shall be constructed to any town, camp or settlement which is wholly transitory or of no substantial value or importance for mining, trade, agricultural or manufacturing purposes." Where the total cost of work on any section of road exceeds $20,000, it must be done by contract, if a bid not unreasonably high is obtained from a responsible party; the work is done by day labor otherwise.

The territory is divided into five districts, with a civil engineer as superintendent in charge of each. The engineer member of the commission is responsible for the execution of the work in conformity with projects developed by the commission as a whole, and similar freedom is given to the disbursing officer.

Progress Report

Alaska had a white population of approximately 40,000, engaged almost exclusively in mining and fishing. The area is nearly 600,000 square miles. When the commission was organized in 1905, there was a primitive mountain road running a short distance from Juneau and a start in road building had been made in the Fairbanks mining district by private subscriptions. Summer travel was only possible on foot or horse-back; most heavy hauling was done in the winter over the snow.

The location of roads and trails gave more trouble than their construction, on account of the unusual local conditions to be satisfied. The roads are earth, except where corduroy or planks surfacing is needed. What is known as the winter sled road type differs from the wagon road in not being crowned, ditched or drained, nor extensively corduroyed, and from the trail in being wider and with better grades and surface. The great obstacles to construction are the permanently frozen ground and the high prices for labor and teams. If some classes of frozen ground are stripped, the exposed surface material will slide in a side hill cutting while on a marsh it may become a quagmire. The problems thus presented must be solved in a variety of ways, in which corduroy construction occupies a prominent place. Ditching in some classes of frozen soil is also very difficult, but is necessary as the ground is very wet on the surface. On the coast line the excessive rainfall and the character of the country traversed make the work more expensive than in the interior.

Roads are cleared for an average width of 24 feet, while the average roadway is 12 feet wide. On side hill roads with light traffic and where corduroy construction is very expensive the width is reduced somewhat, 8 feet being the minimum. As a result of the work done up to 1913, the commission estimated that the saving in cost of transportation effected in that year by the existence of the roads was over $2,100,000.

Up to the close of the working season of 1916, the commission had constructed and maintained 920 miles of wagon roads, 629 miles of winter sled roads and 2,210 miles of trails, at a total expense of $3.390,122.72. Of this sum $1,625,122.72 came from the Alaska fund and the remainder from congressional appropriations. Owing to the burning of the commission's records on July 15, 1915, it is impossible to say how much has been received from a local road tax since repealed and from municipal and private donations. The average cost of wagon roads is $3144.00 per mile, winter sled roads $345, and trails $106. Although none of the roads is classed as an automobile road, about 250 trucks and cars use them. Maintenance charges are heavy on some sections, particularly where summer floods are of large volume.

Funds

Money for road work under the commission is derived from the Alaska fund, congressional appropriations and private donations.

In the fiscal year 1915–16, the Alaska fund yielded $164,402 and the congressional appropriation was $165,000. The expenditures were $300,720. The funds for the fiscal year 1916-17 will be considerably larger, Congress having appropriated $500,000.

Highway Officials

Board of Road Commissioners.—Colonel W. P. Richardson, president; Major P. W. Davison, secretary and disbursing officer; Captain J. C. Mehaffey, engineer officer. Offices, Valdez.

[Approved by Col. W. P. RICHARDSON, Chairman.]

ARIZONA

State Aid Legislation

The State engineer is appointed by the governor by and with the advice and consent of the senate, and is required to be a competent civil engineer. He prepares plans and specifications for State highways and bridges and all State highway work is done under his supervision.

For construction purposes an annual running appropriation of $250,000 is made. Seventy-five per cent of this appropriation is to be expended in the counties in which raised under the direction of the county boards of supervisors and the State engineer; 25 per cent to be expended under the direction of the State board of control (the governor, auditor, and citizen member appointed by the governor), and the State engineer. All engineering expenses to be paid out of the 25 per cent portion, which is called the State road tax fund.

Local Road Legislation

Jurisdiction over public roads vests in a county board of supervisors, who may appoint a county road engineer with a salary not exceeding $3000 a year. State wide-tire legislation is operative only in counties where the supervisors have adopted it. Special road assessment districts, not over 10 miles long and 1 mile wide, may be formed and road bonds issued on it by a vote of the electors.

Convict Labor Laws

State convicts may be used on State highway and bridge construction under the prison labor law which provides $60,000 annually for meeting the cost of such labor. In addition the prison maintenance fund pays into the State road fund an amount equal to the expense of keeping at the prison the number of prisoners employed on the State highways and bridges. Counties in which convict labor is employed are not entitled to any other aid from the State road fund except for engineering purposes.

The State highway department maintained two prison labor camps during the fiscal year 1915–1916; one under the honor and one under the guard system. The cost of their operation in excess of the amounts provided under the Prison Labor Law is borne by the counties in which the work was done from their portion of the 75 per cent fund. In 1915–1916, 9357 days of labor were done in the honor camp at an average cost per working day of $1.517, and 18,561 days in the guard camp at an average cost per working day of $1.64. Both camps have been located from 20 to 35 miles from the nearest railroad point.

Local Bond Issue Legislation

The board of trustees of any road district may, when it is deemed necessary or advisable to expend a larger amount than can be raised by the tax of 75 cents, call an election and submit the question of bonds to the voters of the district. A two-thirds favorable vote authorizes the issuance and sale of bonds, which shall run for not more than twenty years, shall bear interest not exceeding 6 per cent, payable annually and shall not be sold for less than par. The board of supervisors shall levy a tax sufficient to pay interest and retire bonds at the end of their term, although the board may provide for bonds to be retired serially.

Automobile Registration

The law provides for annual registration with the secretary of State. The registration fees are as follows: 25 h.p. and less, $5; 25 to 40 h.p., $10; over 40 h.p., $15; motor cycles, $2; dealers, one machine in each class, at regular rates; chauffeur's license, $5.

The revenues are credited to the State road tax fund. For the year ending June 30, 1916, they were $69,429.

Highway Officials

Board of Control.—Geo. W. P. Hunt, governor; J. C. Callaghan, State auditor; Chas. R. Osburn, citizen member and secretary; Lamar Cobb, State engineer, Phoenix. The staff is under T. F. Nichols, office engineer, and E. P. Adams, chief clerk.

Progress Report

During the year ending June 30, 1916, the expenditures under the direction of the State highway department were as follows: State road fund, $487,085.27; general fund, $5,833.28; total, $492,918.55; refunds, $51,716.38; net total, $441,202.17. Of this amount, $114,548.51 was spent for the construction of bridges, $246,365.92 for the construction of highways, $28,130.39 for maintenance, $26,976.13 for engineering, $9,612.79 for equipment, $856.50 for general expenses in aiding counties and like work, $8,878.65 for administration and $5,833.28 for executive work.

There were 9.58 miles of road graded but not surfaced, 37.45 miles graded and surfaced, 7.6 miles oil-surfaced, 15.25 miles regraded, 1,202 feet of concrete pavement laid, 786 feet of concrete bridges and 60 feet of steel bridges built, 4,683 feet of culverts installed, and 214 miles of road maintained.

During the calendar year 1916 the county road officials spent $1,547,019.

Road Funds

The funds for State highway construction in 1916–1917 comprise an appropriation of $250,000, $70,000 raised under the Prison Labor Law, $90,000 motor vehicle fees and $68,513 from the Federal aid road funds, making a total of $478,513.

In addition the counties will probably spend $626,000 raised by taxation and $400,000 from bond issues, making a total county fund of $1,026,000.

[Approved by LAMAR COBB, State Engineer.]

ARKANSAS

State Aid Legislation

An act approved March 31, 1913, provided for forming the State land office into a department of State lands, highways, and improvements, and created in connection with it a State highway commission and a highway improvement fund. The State highway commission is to consist of three members, as follows: Commissioner of State lands, highways, and improvements, chairman; two members to be appointed by the governor to serve, respectively, one and two years; thereafter, as the terms expire, each commissioner appointed shall serve two years. The existence of the State highway commission is limited to thirty years.

The commissioner of State lands, highways, and improvements is required to appoint a State highway engineer subject to the approval of the commission, who shall be a graduate in engineering of some reputable school of engineering and skilled in road building. He holds office for the term of two years.

A highway improvement fund is created, composed of funds derived from motor-vehicle fees and licenses, being one-half the total $10 fee or $5 per vehicle.

The department is required to collect data, see that road laws are enforced, hold road institutes at least once a year, which county judges, county engineers, and road overseers are required to attend, and for which they are to receive the same pay as if they were engaged in actual road work. The department is required to furnish plans and specifications when requested to do so, and aid in the formation and management of highway improvement districts. The department is authorized to determine the method of distribution of any State road funds that may be available.

The highway improvement districts are created on application to the county courts, giving description of the roads to be improved and the territory traversed by them.

The department is authorized to employ State convicts on the public roads or for public road purposes.

Local Road Legislation

Jurisdiction over roads vests in the county court, of which the probate judge is chairman. Road officials are appointed by him. The per capita road tax may be worked out. A 3-mill road tax levied on all assessed property is collected in cash. Special assessment districts for road construction may be formed upon petition of a majority of the property owners. The cost is assessed upon the property and the work done under the supervision of three commissioners receiving not more than $5 per day each when actually employed.

Local Bond Issue Legislation

The board of commissioners of a road improvement district may issue bonds to run not over thirty years, retired either serially or by a sinking fund.

Convict Labor Laws

The department of State lands, highways and improvements shall employ as many of the State convicts on the public roads as may not be otherwise employed by the penitentiary authorities, the expenses to be borne by the county or improvement district in which they work.

County convicts may be worked upon the highways of the county, and it is lawful to provide in any highway charter for working the male county convicts upon the highways of the county. In case such district is not coextensive with the county from which they come, the county court shall first approve the provision. Special improvement districts may use convict labor and pay a flat rate of 75 cents to the county.

Automobile Registration

The law requires annual registration with the commissioner of State lands, highways and improvements, payment to be made to the county tax collector, whose receipt is forwarded with the application for registration. The fees are as follows: All motor vehicles, $10; dealers, one machine in each class, at regular rate; chauffeur's license, $1.

The revenues are equally divided between the State and the county in which the revenue is collected, the State portion to be credited to the State highway improvement fund. The fees and forfeitures are paid into the general school fund of the county in which they are imposed. (Act No. 134, Laws 1911, as amended by Act No. 302, Laws 1913.)

Highway Officials

State Highway Commission. Five members, of which the commissioner of State lands, highways and improvements, is chairman; appoints a State highway engineer The present State highway engineer is H. R. Carter, at Little Rock.

State Road Funds

Approximate funds available for 1916: automobile licenses and fees from sale of State lands, $60,000; from 3 mill tax and spent by counties, $1,300,000; total $1,360,000; from improvement lists $850,000; grand total $2,210,000.

Approximate funds for 1916: Three-mill road tax, $1,400,000; State and Federal aid funds, $600,000; road improvement district funds, $4,000,000; free labor or per capita tax commutation, $400,000; total, $6,400,000.

[Approved by H. R. CARTER, State Highway Engineer.]

CALIFORNIA

State Aid Legislation

The State provided by a referendum vote of the people, effective December 31, 1910, for a bond issue of $18,000,000 under the "State Highways Act," which defines in a general way the roads to be built. This work is under the general direction of the advisory board of the State department of engineering, consisting of the governor, who is ex-officio chairman; the State engineer; the general superintendent of State hospitals; the chairman of the State board of harbor commissioners of San Francisco; and three members appointed by the governor. It is directly administered by the three appointed members, who are designated by a resolution of the advisory board of the department of engineering as the California Highway Commission, and given by resolution full authority over construction of the system of State highways under the $18,000,000 State bond issue. The highway engineer, appointed by the governor, is the executive officer of the commission, and in his charge is placed the construction of the State highway system.

The State highways, in the language of the act providing the bond issue, are being acquired and constructed through the Sacramento and San Joaquin valleys, and along the Pacific Coast, connecting county seats lying east and west of the main routes. This system is to be constructed and maintained at the expense of the State, except that each county must pay into the treasury 4 per cent per annum upon the sum of money expended in such county in the construction of State highways, less such portion of the amount expended as the bonds matured shall bear to the total number of bonds outstanding. The State highways extend from the Oregon boundary to San Diego and El Centro, the most southerly county seats, and are maintained through funds derived from the State license fee imposed upon motor vehicles.

In 1916, a $15,000,000 bond issue was approved by a four-to-one vote for completing the State highway system contemplated under the 1910 bond issue and adding connecting highways to make the system more comprehensive. Of this amount $3,000,000 will be used on a county-aid coöperative basis in building eight highways.

The State department of engineering has general authority over all participations by the State in works of highway improvement, and is given authority to make investigations regarding highway betterment or extension which may be deemed desirable. In addition to the system of State highways, provided by bond issue, such appropriations are made from time to time for construction of roads of State importance, particularly in mountainous sections and in localities where the sparse population makes the expense an undue legal tax burden.

Local Road Legislation

County supervisors, of whom there are five in each county, elected for a term of four years in November of even years, have authority over roads. The county surveyor is elected.

Local Bond Issue Legislation

Upon petition of a number of freeholder electors of any county equal to 10 per cent of the last vote cast for governor, praying that the issuance of bonds for highway purposes be submitted to the electors, the county supervisors may appoint a highway commission of three members for such county to investigate the main roads and report to the board of supervisors those roads that should be improved, their estimated cost and the amount of bonds to be issued. If this report is approved by the board of supervisors, an election on the issuance of the bonds shall immediately be called. A two-thirds majority vote of the qualified electors is required. The term and rate of interest is not specified in the act. All work done with the proceeds of the bond issue shall be under the direction of the highway commission.

The county supervisors of any county may create road districts under two different acts. *A permanent road district* (act of March 19, 1907) may be created upon the petition of a majority of the land owners of the proposed district, who may, in their petition, propose a bond issue for certain road improvements, and this bond issue shall be submitted by the supervisors to the electors of the district, and if two-thirds of the votes cast are favorable, then bonds of the district shall be issued not to exceed 15 per cent of the assessed valuation, to run not to exceed twenty years, and to bear interest at not to exceed 7 per cent per annum. The bonds shall be sold to the highest bidder at not less than par, and the work authorized shall be done by contract to be let to the lowest responsible bidder. *A special road district* (act of March 21, 1907), for certain specified improvements on established roads may be created by the county supervisors after giving notice of the proposal, if a majority of the land owners of the proposed district do not file objections thereto prior to the date set for hearing objections. Upon the creation of the district, contracts under the approved specifications shall be awarded to the lowest responsible bidder and, upon the completion and acceptance of the work, bonds of the district shall be issued to pay for this work, to run not to exceed twenty years, and bear interest at not to exceed 7 per cent per annum. Under both acts a tax shall be levied to pay interest and principal when due, although in the case of bonds issued by a special road district the county supervisors may make transfers of funds for the payment of interest and principal when due.

Convict Labor Law

An act authorizing the use of convict labor on State highways was passed in 1915. Upon the requisition of the Department of Engineering, the State Board of Prison Directors shall send to the place, and at the time designated, the number of convicts requisitioned, or such portion thereof as are available, in the judgment of the warden. The department of engineering designates and supervises the road work done and provides and maintains necessary camps and commissariats. The State board of prison directors has full jurisdiction at all times over the discipline and control of convicts employed on the State roads. The convicts so employed are compensated by being allowed a reduction of their time to serve in prison, not to exceed one day for each two calendar days that the convict is absent from the prison.

Automobile Registration

A new motor vehicle act became effective on January 1, 1916. Annual registration is required, the application to be forwarded to the motor vehicle department with fee, which issues the necessary number plates, etc., and makes record. Registration fees are as follows:

For the registration of every automobile, except electric motor vehicles, 40 cents for each horse power or major fraction thereof. A graduated fee for every motor vehicle equipped with other than pneumatic tires and used for commercial purposes, according to weights, in addition to regular fees. Electric motor vehicles, $5; motorcycles, $2. Dealers, for each 5 cars operated, $25, and $2 for every automobile in excess of 5 so operated, including the necessary number plates. Motorcycle dealers, $5. Chauffeur's license, $2.

The maintenance of the State and certain county roads is taken care of by a fund collected from the license tax on motor vehicles. During 1916 approximately $2,136,000 was collected. After deducting the cost of licenses and collection, half the money is used for the maintenance of State highways and the other half divided among the counties of the State in proportion to the amount collected from each county for licenses, this amount to be used in the maintenance of county highways.

Highway Officials

State Highway Commission, Sacramento.—Newell D. Darlington, Los Angeles, chairman, Chas. F. Stern, Eureka, Charles D. Blaney, Saratoga.

Austin B. Fletcher, formerly the secretary and chief executive officer of the Massachusetts highway commission, is the highway engineer and executive officer of the commission. Wilson R. Ellis of Berkeley is secretary of the commission.

The headquarters office is at Sacramento and the division offices are maintained in San Francisco, Los Angeles, Dunsmuir, Fresno, San Luis Obispo and Willits.

Progress Report

The State highway work under the $18,000,000 bond issue of 1910 has been in progress since the spring of 1912. On January 1, 1917, the system included 1562 miles of the following types: Concrete base with asphalt surfacing, 5.41 miles; concrete base with Topeka surfacing, 18.08 miles; concrete base with thin bituminous surfacing, 864.85 miles; macadam base with Topeka surfacing, 16.54 miles; oiled macadam roads, 158.46 miles; asphaltic concrete, 10.37 miles, bridges, 0.84 mile; graded roads otherwise unimproved, 334.52 miles; unfinished roads with concrete base and thin bituminous surfacing, 77.03 miles; unfinished graded roads otherwise unimproved, 76.13 miles. The uncompleted roads will be finished in 1917.

No work had been started on January 1, 1917, under the $15,000,000 bond issue.

[Approved by AUSTIN B. FLETCHER, State Highway Engineer.]

COLORADO

Good Roads Legislation

The State highway commission consists of a highway commissioner, appointed by the governor, and an advisory board of five members, holding office from one to five years, respectively. The commission is required to meet four times a year and to appoint a secretary, who is required to be a civil engineer and a practical road builder, to hold office at the pleasure of the commission. The commission is required to prepare a map showing the public roads in each county connecting the roads of sufficient importance to receive State aid and form a connecting system of State roads. The commission is given authority to designate the most important roads as the first to be improved. They are also authorized to make investigations to ascertain the location of road material, etc. The commission is given authority to apportion the State road fund among the counties, taking into consideration area, amount of money expended in construction, difficulty and extent of such construction, and extraordinary expenses in connection with the development of new territory. The counties receiving such aid are required to raise an amount equal to the amount set aside by the State, unless the State highway commission should desire to extend further aid to poorer counties, in which case they may extend it to the extent of $5 of State money to $1 of the county's. All money apportioned to counties and not accepted by them is distributed to other counties. The county commissioners are to designate the roads to receive State aid, subject to the approval of the State highway commissioner. The county commissioners must make surveys, prepare plans and specifications, and make estimates and submit them to the State highway commissioner for approval. Contracts are let by the county commissioners after approval by the State highway commissioner. Construction and maintenance are under the supervision of the county commissioners, subject to the approval of the State highway commissioner. The money apportioned by the State highway commission shall be paid to the treasurer of the county on estimates from the State highway commissioner as the work progresses. Annual reports must be made by the county commissioners to the State highway commissioner of all moneys expended on roads during the current year.

Appropriations for State highways are made directly by the legislature.

Local Road Legislation

In each county a board of three county commissioners serving 4-year terms has jurisdiction over local roads. They may appoint a general overseer for all such roads or divide the county into districts and appoint a district overseer for each.

An act of the legislature passed in 1913 providing that the county commissioners in counties having a revenue of $12,000 or more may elect a county road supervisor to have entire supervision of all the roads and bridges in the county. He is required to make a complete report on the first of each month, which report after approval by the county commissioners is forwarded to the State highway commissioner. He is required to attend at least one meeting annually at the capitol called by the State highway commissioner.

Local Bond Legislation

When the county commissioners of any county shall deem it necessary to create a county indebtedness for road and bridge purposes, they may submit the proposition to a vote and, if a majority of the votes cast are in favor of the proposition, they may issue bonds of the county in the aggregate not to exceed the following: Counties of assessed valuation less than $5,000,000, $3 on each $1000; and counties of assessed valuation over $5,000,000, $1.50 on each $1000. These bonds shall bear interest not exceeding 10 per cent per annum and shall be payable at the pleasure of the county after ten years, but absolutely due and payable twenty years from the date of issue. To pay the interest on such bonds, an annual tax shall be levied by the county commissioners, and for their ultimate redemption the county commissioners shall levy annually, after ten years, a tax upon all taxable property in the county in such an amount as to create a yearly fund equal to 10 per cent of the whole amount of the bonds. The proceeds of these bonds shall be used only for the purpose for which they were issued. (Constitution, article xi, Section 6.)

Under Section 1364, revised statutes of 1908, the aggregate amount of road and bridge bonds in counties with an assessed valuation of $1,000,000 to $5,000,000 is fixed at $12 per $1000, and in counties with over $5,000,000 assessed valuation at $6 per $1000.

Convict Labor Laws

At the request of the board of county commissioners the warden of the State penitentiary shall detail such a number of prisoners to work on the public roads as he shall deem proper. The additional cost of guarding and other expense must be borne by the county.

Automobile Registration

Annual registration with the secretary of State is required· The fees are as follows: 20 h.p. and less, $2.50; 21 h. p. and 40 h.p., $5; 41 h.p. and over, $10; motorcycles, $2; chauffeur's license, $1.

Revenues are divided equally between the State and the county from which the revenue is received. The State's portion is credited to the State road fund, to be expended in improving and maintaining State roads, and the counties' portion is credited to the road fund of such county. Fines and forfeitures are divided equally between the State and the county and credited in the same way as the registration fees. (Act No. 49, Laws 1913.)

Highway Officials

State highway commissioner. T. J. Ehrhart, of Denver, Colorado. There is an advisory board of five members, composed at this time of J. M. Kuykendall, chairman, Denver; Leonard E. Curtis, v. chairman, Colorado Springs; Fred J. Radford, member, Trinidad; L. Boyd Walbridge, member, Meeker; Frederick Goble, member, Silverton, and secretary and engineer, J. E. Maloney, Littleton; stenographer, A. A. Ross, Denver.

Progress Report

The total length of roads in the State is estimated to be 40,000 miles, of which 1008 miles are estimated to be hard surfaced and 8000 to be improved. No roads have been completed entirely at the expense of the State, but it is estimated that 6000 miles have been improved partly at the expense of the State and partly at the expense of local sub-divisions. An additional 600 miles are in course of improvement jointly by the State and sub-divisions. No roads are maintained at the expense of the State but there are approximately 6000 miles maintained under the direction of the county commissioners for which the State pays a portion of the cost. There were 2100 miles of road graded and drained and about 295 miles of road surfaced with gravel, shale, sand or clay, under the direction of the State highway commission during the calendar year 1916. The total expenditure of State funds on State roads during 1916 was $769,250, and of county funds on these roads approximately $441,496, making a total expenditure on State road system for the year of approximately $1,211,446.

Five convict camps of approximately 50 men each were worked on the roads in different portions of the State during the year.

The grading and ditching on the 2100 miles of State road during 1916 averaged about $346 per mile. About 170 bridges were built, of steel and reinforced concrete, at an average cost of $1030 each; 1620 culverts were placed at an average cost of about $43 each. The 295 miles of road surfaced with gravel, shale, sand or clay averaged about $415 per mile. The balance of the expenditure is for dragging and maintenance, engineering and administration. The expenditure on county roads of the State amounted to about $1,042,000, on some 33,000 miles of road. Work has been in progress in every county in the State and the main passes have been improved so as to permit travel with comfort. The road over Wolf Creek Pass to Mesa Verde National Park was opened this year and autos can make the trip to the Cliff dwellers ruins now.

Road Funds

The funds available for expenditures by this department will amount to about $750,000 for this year.

In meeting this amount the counties will put up probably about $500,000. This amount will be spent on the State road system. In addition to this, the counties will raise by their tax levy for roads and bridges about $1,000,000 which will be spent on all roads other than State roads, or a total of $2,250,000, although it is possible that about $250,000 of this latter amount may be diverted to use upon the State road systems. The sources of the State fund are as follows: One-half mill levy for State road purposes, will yield approximately $600,000 (part of this fund anticipated); receipts from automobile license, $100,000; amount received from the internal improvement income and permanent fund, $50,000. The county fund is raised entirely by direct levy for roads and bridge purposes.

[Approved by J. E. MALONEY, secretary and engineer, State highway commission.]

CONNECTICUT

State Aid Legislation

A State highway commissioner, who shall be a capable road builder, is appointed by the governor with the consent of the senate and holds office for four years. He has a right to enter any town in the State and lay out and improve any trunk line roads and certify the cost of the same to the State comptroller for payment. He has authority to approve the application of the selectmen of any town for State aid, to select the highway to be improved with such aid, make surveys, plans and specifications therefor, determine the character to the road, and have supervision of the construction. He has the right to reject any and all bids, and where the cost is less than $1000 he may at his discretion, permit the town to do the work. He shall keep all State roads in repair and certify the cost of the comptroller. He is authorized to appoint a deputy commissioner, eight division engineers, and such other assistants as he may deem necessary and fix their salaries.

Whenever any town desires to improve a public road by the aid of the State the selectmen of the town shall make application to the State highway commissioner for such aid, such application to be subject to his approval. The aid granted by the State is apportioned as follows: In towns having a taxable valuation of over $1,250,000 the State pays three-fourths of the cost of roads constructed as State aid roads, and in towns having a valuation of $1,250,000 or less the State pays seven-eighths of the cost of such construction. The law permits the use of two years' appropriation in one year. A trunk line system, comprising the principal roads of the State, is gradually being constructed and maintained entirely at the cost of the State. The State highway commissioner is authorized to lay out, widen and grade any highway in the State whenever he deems it necessary for the purpose of connecting with the trunk line highways. Under the new law, towns are permitted to improve State aid roads with their own funds and recover their proportion of the cost of said improvement under a subsequent appropriation by the State. Said work must be done under the supervision of the State highway department and must not exceed an amount designated by said department.

The maintenance of trunk-line roads is paid for entirely by the State, while the maintenance of State roads other than those on the trunk lines is borne by the State and town in the ratio of three-fourths and one-fourth respectively. All moneys received by the State from automobile licenses and fines are applied for road maintenance. A law of 1915 directs the highway commissioner to erect and maintain uniform direction and danger signs on trunk line highways.

A law of 1915 provides that the highway commissioner may petition the public utilities commission for authority to eliminate dangerous conditions on trunk line highways. This is a distinct departure from the previous policy of the State.

Local Road Legislation

Local road work is under the board of selectmen of each town, selected annually. If they refuse or neglect to maintain the roads, the board of county commissioners may order the work done, when petitioned to do so.

Bridges

The legislature of 1915 passed a law which places under the jurisdiction of the highway department all trunk line highway bridges having a span greater than 25 feet, whether these bridges are located on improved sections of road or not. When bridges are between two towns or two counties, the State pays half of the cost and the two towns or counties the other half. When any lines of an electric street railway company cross such bridge, the expense is divided one-third by the State, one-third by the railway company and one-third by the town or towns.

A law of 1915 directs the highway commissioner to investigate the condition of all bridges having a span greater than 25 feet on trunk line highways and to file a report with the General Assembly of 1917.

Automobile Registration

Annual registration with the secretary of State is required. Registration fees are as follows:

Automobiles, 50 cents per horse power; motor vehicles, $2; registration of all motor vehicles owned by a dealer in automobiles and motor trucks, $50; registration of all motor vehicles owned by a dealer in motorcycles, $10; substitution of the registration of a motor vehicle, except a motorcycle, previously registered, $1; substitution of the registration of a motorcycle, 50 cents; for each motor vehicle engine owned by a manufacturer of motor vehicles and tested or operated on the highways of this State, $1; minimum charge to any manufacturer, $25.

Commercial motor vehicles

CAPACITY		CAPACITY	
pounds		*pounds*	
1,000	$11.00	11,000	$87.50
2,000	15.00	12,000	100.00
3,000	20.00	13,000	112.50
4,000	25.00	14,000	125.00
5,000	30.00	15,000	150.00
6,000	35.00	16,000	175.00
7,000	45.00	18,000	200.00
8,000	55.00	20,000	225.00
9,000	65.00	Each additional ton...	50.00
10,000	75.00		

Highway Officials

State highway commissioner, Charles J. Bennett, Hartford; deputy highway commissioner, Richard L. Saunders, Hartford; superintendent of repairs, W. LeRoy Ulrich, Hartford; chief clerk, Clinton G. Nichols, Hartford; division engineers: Robert S. Hulbert, Winsted; Elmer C. Welden, New Haven; Carrol A. Campbell, Middletown; George E. Smith, New Milford, Arthur W. Bushell, Norwich; Robert W. Stevens, Hartford.

Progress Report

During the year ending September 30, 1916, expenditures for road work have been as follows: State aid construction, $141,528.40; trunk line construction, $181,554.30; maintenance and reconstruction, trunk line roads, $1,136,262.70; maintenance and reconstruction, state aid roads, $178,765.68.

The appropriation for 1916 for the maintenance of State aid roads was $150,000 and for the maintenance and reconstruction of trunk line highways $500,000 plus automobile receipts amounting to $768,727.91.

[Approved by CLINTON G. NICHOLS, Chief Clerk, State Highway Commission.]

DELAWARE

State Aid Legislation

There are three counties in the State one of which, New Castle County, has a State highway commissioner for the county, appointed by the governor.

Local Road Legislation

Jurisdiction over the local roads in New Castle and Kent Counties vests in the county courts, called levy courts, which appoint the county road engineers. In Sussex County a commission of three members have charge of roads. State wide-tire legislation is only operative where the county courts have adopted it. A rebate from property road taxes is granted to those complying with the wide-tire law.

Convict Labor Laws

In the counties of Kent and Sussex, vagrants and minor criminals may be sentenced to hard work on the county roads.

In New Castle County, the levy court is empowered to arrange for employing any of the able bodied convicts on the public roads.

Automobile Registration

The law provides for annual registration with the secretary of State. The schedule of fees is as follows: Motor cycles, $3; all other motor vehicles, $5; operators, including owners, $5; manufacturers and dealers, for each car demonstrated on the roads, $5.

Registration revenues are credited to the general fund of the State treasury.

Highway Officials

New Castle County Levy Court.—T. S. Fouracre, Middletown, president; R. M. Burns, Wilmington; W. T. Purks, Wilmington; I. C. Elliott, Wilmington; B. A. Groves, Marshallton; J. G. Shaw, New Castle; J. A. Buckson, Blackbird.

New Castle County State highway commissioner, James Wilson, who is a State official, and has charge of the building of improved roads and is also county engineer.

Kent County.—W. Hart Scott, county engineer, Dover.

Sussex County Commission.—W. E. Valliant, Laurel; F. W. Holloway, Millville; W. J. Mustard, Georgetown.

[Approved by JAMES WILSON, State Highway Commissioner.]

DISTRICT OF COLUMBIA

Control of Roads

The commissioners forward to congress, through the secretary of the treasury, estimates of proposed expenditures for each fiscal year ending June 30. To the extent to which these estimates are approved, inasmuch as the National government owns fully one-half in value of the property in the District, congress appropriates 50 per cent, and a like proportion is paid from the District revenues.

Automobile Registration

Regulations provide for registration with automobile board. Schedule of fees is as follows: All motor vehicles, registration, $2; operators, including owners, $2; dealer's license for each machine demonstrated, $2.

Progress Report

The extent of streets and roads in the District on June 30, 1914, and June 30, 1915, was:

Pavements	*1915 miles*	*1916 miles*
Asphalt	154.54	159.42
Asphalt block	30.17	30.59
Granite block	25.24	23.93
Cobble	3.98	3.31
Vitrified block	1.34	1.34
Bituminous concrete	7.26	7.26
Cement concrete	3.00	3.75
Bituminous macadam	4.36	4.36
Waterbound macadam	118.98	118.42
Gravel and dirt roads	161.42	161.31
Total	510.19	513.69

Highway Officials

Engineer Commissioner in charge of all public work, Col. C. W. Kutz, U. S. A.; surface division is in charge of Capt. J. J. Loving, U. S. A., assistant to the engineer commissioner; engineer of highways, C. B. Hunt.

Road Funds

About $440,160 is available for the current fiscal year for construction and maintenance of suburban roads.

FLORIDA

State Aid Legislation

A State road department, created by the legislature of 1915, was organized October 15, 1915, consisting of five members, who will serve 4-year terms, except for three of the first members. They receive no compensation, but are paid their actual expenses. The headquarters of the department is in Tallahassee, Florida. The State does not grant financial aid to road construction.

The State road department is authorized to employ a State road commissioner, who is required to be "a competent and efficient road builder and well versed in the building of good roads." He is required to visit the several counties and inspect their roads and methods of construction. Where county commissioners request the advice of the department in the construction or repair of roads, the department is required to send the road commissioner or an assistant into the county to render all assistance practicable, without expense to the county.

The law creating the department provides: "In all cases where the department shall learn that road repair or construction work is being improperly or extravagantly done, or improper or inferior materials are being used in such work, in any county, so as to cause a loss or waste of public funds, it shall be the duty of the department to notify the county commissioners of the same, and point out to them the defects discovered, and if, after such notice is given, the county commissioners continue in the use of such improper methods or materials, the matter shall be reported to the governor by the department."

The department is maintained by a special fund derived from 15 per cent of all county licenses upon automobiles and other motor-driven vehicles, this amount being remitted by the counties to the State treasurer.

Local Road Legislation

Jurisdiction over roads vests in elected boards of county commissioners, who appoint three road trustees annually for each road district. Road taxes may be worked out. Special road and bridge districts may be created by election, but the special taxes are levied and collected by the county boards. When the electors vote to make their road district a special tax district, they elect at the same time three trustees to supervise the road work.

Wide-tire ordinances are operative only where adopted by county officials.

Local Bond Legislation

Upon a petition of 25 per cent or more of the registered voters or freeholders residing in any territory embraced wholly or in part in one or more road districts, praying that this territory shall constitute a special road and bridge district for the purpose of improving roads and bridges therein by the levy and collection of special road and bridge taxes or by the issue and sale of bonds, the board of county commissioners shall order an election thereon, and a favorable majority vote shall be necessary to authorize this arrangement. If, at this election, bonds are authorized to pay for such improvement, the board of county commissioners shall issue and sell these bonds and levy an annual tax to pay the interest and create a sinking fund for their redemption.

Convict Labor Laws

The county commissioners may employ all convicts in jail under sentence for crime at labor upon the streets of cities and towns or upon roads, bridges and public works; or the board may hire out convicts. Colored male State prisoners are subject to road work if leased to the boards of county commissioners of the various counties, who, under Acts of 1913 and 1915, have the preference over private lessees. First-grade prisoners (that is, able-bodied men) are leased to the counties at the rate of $10 per month, and third-grade prisoners at the rate of $1 per month. By third-grade prisoners is meant those whose physical condition does not permit them to work in a turpentine camp, but who are capable of performing reasonable labor on the public roads; it also includes all able-bodied colored male State prisoners who have actually served 10 years or more of their sentence.

Automobile Registration

The license fees for motor cars and trucks, established by an Act of 1915, are based upon the seating or carrying capacity of the vehicle, as follows:

NUMBER OF PASSENGERS	PRIVATE USE	FOR HIRE
One or two	$3	$10
Three, four or five	5	20
Six to ten inclusive	10	30
Eleven to twenty inclusive	15	40
Over twenty	25	60
CARRYING CAPACITY		
1000 pounds or less	$10	$15
1000 to 2000 pounds	20	30
2000 to 3000 pounds	30	40
3000 to 5000 pounds	40	50
Over 5000 pounds	50	60

All motor cycles pay a license of $2.

Highway Officials

Ed. Scott, Arcadia, chairman; F. O. Miller, Jacksonville; W. J. Hillman, Live Oak; J. D. Smith, Marianna; M. M. Smith, Orlando; secretary, J. D. Smith; Wm. F. Cocke, Commissioner; J. P. Clarkson, Chief Clerk.

There are no civil service regulations applicable to road officials.

Progress Report

Road construction by counties has been very active recently, about $11,000,000 having been raised for the purpose by bond issues. During 1916 about 800 miles were improved.

Road Funds

For 1917 it is estimated that $2,623,000 will be available from county and road district bond issues, $1,500,000 from taxes, and $168,000 from Federal aid road funds, making a total of $4,291,000.

[Approved by Wm. F. Cocke, State Highway Commissioner.]

GEORGIA

State Aid Legislation

Georgia gives no State funds for road work, but State convicts are employed on county roads, as explained hereafter. A State highway department was established in 1916 to meet the requirements of the Federal Aid Road Law, and adopted shortly after organization a five-year program of road construction, contemplating an expenditure of about $8,000,000 on 5500 miles of road.

Local Road Legislation

Jurisdiction over roads vests in elected boards of county commissioners. The counties are divided into districts, and road supervisors in each are appointed at the discretion of the county commissioners. Road poll taxes are sometimes worked out, but usually are commuted.

Convict Labor Laws

Convicts guilty of misdemeanors may be sentenced to work in the chain-gang of the county. All felony convicts except such as are required by law to be kept at the State farm may be employed in the several counties. On or before February 10 annually, the prison commission shall communicate with the county authorities and ascertain those counties desiring to use convict labor. Convicts shall be apportioned according to public road mileage. In 1916, about 7000 convicts were used on road work.

Highway Officials

The State highway department consists of the State prison commission, which has authority to employ engineers, the State geologist, the dean of the college of civil engineering of the State University and the professor of highway engineering of the Georgia School of Technology. They serve without additional compensation. The members are Judge T. E. Patterson, chairman, E. L. Rainey, R. E. Davison, Dr. S. W. McCallie, Prof. C. M. Strahan and Prof. R. D. Kneale. The secretary is G. H. Yancey and the offices are at the State capitol, Atlanta.

Automobile Registration

The law provides for annual registration with the secretary of State. Registration fee for all motor vehicles is $5. The net revenue from registration is paid into the State treasury and kept as a separate fund. The said fund is apportioned to the several counties in the State in proportion to the number of miles of rural mail route in such counties.

County commissioners or ordinaries are required to ascertain by actual measurement the mileage of rural mail routes traveled in the county and to report same to the secretary of state. Any county misrepresenting the facts, or in which as many as 10 per cent of the motor vehicles therein are not returned for taxation, shall forfeit its right to share in the distribution of said fund for that year. (Act No. 478, Laws, 1910, as amended by Act of August 19, 1913; Act No. 431, Laws 1914.)

Progress Report

The following data regarding roads in 1914 were collected by the State Geological Survey and the U. S. Office of Public Roads and Rural Engineering in 1915: Total mileage of public roads, 99,606; miles of sand-clay and top-soil roads, 11,923; macadam roads, 321; chert and gravel roads, 1173; other surfaced roads, 167; improved earth roads, 38,268; unimproved earth roads, 47,754.

In 1914 the total revenue for Georgia roads and bridges was $6,342,377, made up of the commutation tax of $708,285, the property tax of $2,827,353; the automobile license fund of $92,739, bond issues of $68,000, and $2,646,000 of convict labor, estimated at $1.25 per day. This is equivalent to about $63.67 per mile of public roads or $2.43 per capita.

In 1915 about $4,000,000 was spent on roads and bridges, and in 1916 about $5,000,000.

Road Funds

The plans for the road work under the State highway department provide for an expenditure in 1917 of $134,329.48 of federal aid road money and about the same sum from county funds. The total expenditures on roads and bridges in 1917 are expected to exceed $5,000,000.

[Approved by Prof. C. M. STRAHAN, Member State Highway Department.]

HAWAII

State Aid

The territory of Hawaii has done considerable construction of roads since 1911, through commissions appointed by the governor in each county. It has also constructed roads in opening up tracts of land for homesteads. All other roads are under the jurisdiction of the five counties.

Road Funds

There is a vehicle tax of $1 on bicycles, $2 to $5 on carriages and carts, and 1 cent a pound on automobiles, all paid into the county road fund. There is also a road poll tax of $2.

During the year ending June 30, 1916, the department of public works paid $10,145 on contracts carried forward from the previous year and $27,753 on contracts made during the current year and for road supplies, and had liabilities of $53,913 on unfinished contracts. Contracts amounting to $43,763 were under way for local commissions. Some work has been done by prisoners.

Officials

Governor, L. E. Pinkham; superintendent of public works, C. R. Forbes; engineer, W. C. Woodward. Offices, Honolulu.

IDAHO

State Aid Legislation

The original highway department was created by the 1913 legislature. The 1915 legislature passed a bill recreating the State highway department. The State highway commission now consists of three members, two of whom are civilian members appointed by the governor, and the third member is the secretary of State, who is ex-officio secretary of the commission. The engineering department is under the direction of a State highway engineer appointed by the commission. The construction work is carried on by the State in conjunction with the counties and highway districts. In all counties, and in highway districts with an assessed valuation of over $1,000,000, the State pays one-third the cost of highway construction, and the county or highway district the balance. Where the assessed valuation of a highway district is less than $1,000,000, the cost of construction is divided equally between the State and highway district. All contracts are let by the State highway commission and the work is done under the direction of the State highway engineer. After the completion of the roads, they are maintained at the expense of the State.

Local Road Legislation

Jurisdiction of roads vests in boards of county commissioners, elected, who divide their counties into districts and appoint one or more overseers for each.

The wide-tire law is operative unless suspended by a county board.

Bond Legislation

There are in Idaho two classes of road districts that are authorized by law and may issue bonds. Since 1905 it has been lawful for any portion of a county containing twenty-five or more resident taxpayers, by a majority vote of the resident freeholders at an election ordered by the county board of commissioners and petitioned for by a majority of the freeholders, to organize and become a good roads district. Three good roads commissioners are also chosen at this election, who are authorized, with the consent of two-thirds of the qualified freeholders expressed at an election, to issue bonds in any amount not exceeding 25 per cent of the assessed real property valuation in the district, and the proceeds must be used exclusively for road purposes. These bonds shall bear interest not to exceed 6 per cent, shall run for not more than twenty years, and shall not be sold for less than par.

Under an act of 1911, fifty or more freeholders of lands wholly within a county aggregating 20,000 acres or consisting of less contiguous territory that has an assessed valuation of $1,000,000, provided that these freeholders own at least 10 per cent of all the property in the proposed district, or a number of resident freeholders equal to 20 per cent of the last vote cast for governor may petition the county board of commissioners for an election at which the majority vote decides. If the vote is favorable, a highway district is organized with three highway commissioners, with terms of four years each, and the first of these commissioners are appointed by the governor, while their successors are elected. The commissioners constitute a highway board and have authority by resolution to issue coupon bonds for road purposes at not exceeding 6 per cent interest, and payable within twenty years by sinking fund provided therefor. If these bonds increase the outstanding bonded debt of the district, the resolution shall provide for an election, and a two-third vote is necessary to carry the election. In highway districts the amount of the bond issue shall not exceed 10 per cent of the assessed valuation of all property in the district.

A good roads district may become a highway district in the same manner as any unorganized territory.

Convict Labor Laws

The highway commission is authorized to make requisition upon the warden of the State penitentiary for convicts for road labor, subject to such rules and regulations as the board of prison commissioners shall prescribe. The warden and prison commission shall assign such prisoners as they deem physically able and at the same time reasonably safe to work on the State roads under the general direction of the highway commission, and the prisoners shall be paid $5.00 monthly for their services.

Automobile Registration

The law provides for annual registration with the secretary of the State highway commission. The schedule of fees is as follows: 30 h.p. or less, $15; 31 to 40 h.p., $20; 41 to 50 h.p., $25; 51 h.p. and over, $40.00; motor cycles, $5.00; dealers and manufacturers, $35; chauffeurs, $2.

Motor vehicle licenses are collected by the assessors of the various counties. The counties retain 75 per cent of the fees to be used on the county roads, after deducting enough to pay the interest on any road bonds which may be outstanding. The remaining 25 per cent is forwarded to the State treasurer who deducts 10 per cent of this amount to pay the interest on outstanding State highway bonds, and the balance is used for State highway maintenance.

Highway Officials

The State highway commission consists of W. A. Brodhead, chairman; E. A. Van Sicklin, vice-chairman, and W. T. Dougherty, ex-officio, secretary. The State highway engineer is E. M. Booth, Boise.

Progress Report

During 1916 the grading work on about 200 miles of State highways was completed, and a large amount of work is contemplated for 1917. About 35 miles of sand-clay and gravel surfacing was done in 1916. This work involved the expenditure of approximately $450,000.

Road Funds

No funds for State highway construction are now available, the revenue from the motor vehicle license tax being barely sufficient for maintenance purposes. The highway commission has recommended that the 1917 session of the legislature provide $1,500,000 for State highway construction during 1917 and 1918, and make use of all Federal aid funds allotted to the State.

[Approved by E. M. BOOTH, State Highway Engineer.]

ILLINOIS

State Aid Legislation

All roads or bridges built, repaired or improved at the joint expense of the State and one or more counties are termed "State Aid Roads" and the money appropriated by the State for such purposes is termed the "State Road and Bridge Fund." A State highway commission of three members, one appointed by the governor every two years and each serving six years, has general supervision of State aid roads, prescribes the regulations governing the State highway employes and the county highway superintendents, aids the county highway superintendents and town and district highway commissioners in establishing grades and drainage systems and the general construction and maintenance of roads and bridges, studies the various methods of meeting the road and bridge requirements of all parts of the State, has the final approval of final plans, specifications and estimates of State aid roads, and lets all contracts for their construction or improvement.

The administrative and technical agents of the commission are a chief State highway engineer and an assistant State highway engineer, appointed by the governor for a 6-year term. They also act as technical advisers to county, township or road district officials.

The State pays one-half the cost of State aid roads and the counties the other half. A majority of the entire county board may specify the type of construction of a road built under the State aid laws, "which decision shall be final and not subject to change by the State highway commission, whether of permanent earth improvement (including surface or sub-surface drainage, grading, leveling and crowning), gravel, macadam, concrete, concrete and macadam combined, or brick. The final decision must not be made until the board has obtained from the State highway commission detailed estimates of the cost of the different types and has published them in two county newspapers. In case a board cannot agree on a type of construction or does not care to choose, the State highway commission specifies the type. When a type has been selected it "shall be adhered to throughout the entire length of such road, that is, from one main objective or connecting point to another within the county." The State and county may, however, jointly change an earth, gravel or macadam type of road to a more permanent one at any time. One-half the maintenance expense of a gravel or macadam State road must be paid by the county and the entire maintenance expense of an earth road.

In preparing estimates, the State highway commission may require to be included the value of any materials or the fair rental of any equipment which the State is to furnish. The State highway engineer may call upon county highway superintendents for aid in preparing the plans, specifications and estimates. The estimates must include cost of land obtained by private agreement or condemnation proceedings.

No contract for a State aid road can be signed until the money to pay the State's half of the cost has been paid into the State road and bridge fund.

Local Road Legislation

In each county there is a county highway superintendent, appointed by the county board after a competitive examination for the place held by the State highway commission, preference being given to a resident of the county. No part of the State road and bridge fund may be apportioned to a county until it has appointed such a superintendent. His term is 6 years and he is regarded as a deputy to the State highway engineer. In case the office is vacant and a temporary emergency requires some qualified official to discharge the duties, the State highway engineer may appoint somebody to perform these duties temporarily.

The county highway superintendent prepares the plans, specifications and estimates for all county bridges, subject to their final approval by the State highway commission, supervises the construction and maintenance of all roads and bridges under exclusive county control or joint county and town or district control, makes at least one inspection annually of each road or bridge in the county, and as many more as the State highway officials direct, advises the town or district highway officials on the maintenance and improvement of roads and bridges, and supervises the maintenance of State aid roads in the county under the direction of the State highway commission.

The supervisors of a county under township organization or the commissioners of a county not so organized had the original right to designate the roads to receive State aid. These were required to be "as nearly as possible those highways connecting the principal cities and trading points in each county with each other, and also with the principal cities and trading points in other counties." These routes were then examined by the State highway commission, and changes desired in them were submitted to the county officials, who appeared before the commission, if they wished, to discuss the changes. The State highway commission made the final selection of the routes, after this hearing. In case the county officials failed to select routes within 6 months of the passage of the law, the State highway commission was authorized to make the choice.

The control of local roads is exercised in two ways. In counties not under township organization, the county boards divide the territory into road districts which are the local administrative units for highway purposes exclusively. In counties under township organization, the several towns have authority over the roads. In either case, the roads are in charge of a highway commission of three members serving three-year terms. The local road tax rate of a town or district is determined by its commission annually. Any contract for construction, machinery or materials exceeding $200 must be approved by the county highway superintendent. One of the unusual requirements of the law makes it the commission's duty "to prevent thistles, burdock, cocklebura, mustard, yellow-dock, Indian mallow and jimson weed from seeding, and to extirpate the same so far as practicable." Any town or road district may substitute by vote a single highway commission for a board of three commissioners.

Road Funds

The annual allotment of State road funds to a county bears the same ratio to the whole appropriation that the total road and bridge tax of the county does to the sum of such taxes in all counties, except in counties where over 40 per cent of the total amount appropriated for roads by the legislature is collected, including automobile licenses, the allotment of State funds shall equal 25 per cent of the amount so collected in each of the counties. State aid is not permitted to exceed half the cost of an improvement. A county which does not appropriate within 6 months of the date of the State allotment at least an equal sum, forfeits its allotment, which is distributed among the counties fulfilling the law.

If a county desires to construct a State aid road more rapidly than funds can be provided in the manner just indicated, the law authorizes the county to advance the necessary funds and construct the road at any time. In this case, any allotment of State aid funds may be used either to defray half the cost of new roads or to pay off county bonds or other obligations issued to construct State aid roads at the county's expense, provided the total State aid used in the latter way does not exceed half the cost of constructing such roads, which must comply when finished with the plans, specifications and estimates of the State highway engineer. Bonds so issued must be specifically authorized by a majority vote of the electors and must mature in not less than 10 nor more than 20 annual series.

There is an annual highway poll tax of $1 to $3 in each town or road district, payable to its treasurer by every able bodied male resident, unless this form of taxation for local roads is abolished by vote of the electors of the town or district. The property tax for local highway purposes must not exceed 61 cents on each $100 valuation plus an allowance of not over 20 cents per $100 to pay for property damages incident to road improvements. Towns and road districts may issue bonds to pay for road and bridge improvements. Not less than $3 or more than $5 per mile per annum of the road funds of a town or road district must be used for dragging earth roads.

Convict Labor Laws

Prior to 1915, convicts were not worked outside prisons except in quarries getting out rock for State use. Crushed rock and other road material produced by convict labor is furnished free at the penitentiary where prepared to the State highway commission for permanent road improvements. In 1915 convicts were worked on local roads on requisition from town highway commissioners, a charge of 50 cents per man per day being made for board. Three or four convict camps were worked and about 25 miles of macadam road constructed by them.

Automobile Registration Laws

The law provides for annual registration with the secretary of State. The schedule of fees is as follows: 25 h.p. or less, $4; 26

to 35 h.p., $6; 36 to 50 h.p., $8; over 50 h.p., $10; all electric motor vehicles, $5; motor cycles, $2; manufacturers and dealers, $15; chauffeur's license, original, $5.

Registration revenues are paid into the State treasury and credited to the State road fund for expenditure only in the construction of permanent roads. Fines and forfeitures are paid into the treasury of the road district, town or city in which collected and credited to the road fund. (Chapter No. 121, Code of 1912, as amended by Act of June 28, 1913.)

Highway Officials

State Highway Commission.—A. D. Gash, president; S. E. Bradt, secretary; James P. Wilson. Chief State highway engineer, Wm. W. Marr; assistant State highway engineer, P. C. McArdle, on leave of absence as highway engineer of Vermilion county; road engineer, H. E. Bilger; bridge engineer, C. Older; B. H. Piepmeier, maintenance engineer; F. L. Roman, testing engineer; chief clerk, J. M. McCoy.

With the exception of the State highway commission, chief State highway engineer and assistant State highway engineer, all persons employed on State road work are subject to the Illinois civil service laws.

Progress Report

Under the State aid system which became operative July 1, 1913, there were either completed or awarded up to January 1, 1917, 458 miles of State aid roads. Of this amount there are 163 miles of Portland cement concrete; 58.2 miles of brick; 1.51 miles of bituminous concrete; 12.25 miles of bituminous macadam; 12.78 miles of waterbound macadam; 26.53 miles of gravel; 102 miles of oiled earth; 75.8 miles of plain earth grading and 5.97 miles of bituminous resurfacing. The total cost of this work was $3,851,641.00. In addition to this, there have been either built or placed under contract during this period 405 bridges and culverts at a cost of $248,752.00.

Under the State aid system, during 1916, contracts were awarded for 282.47 miles of State aid roads. Of this amount, there are 15.54 miles of concrete roads 10 feet wide, 4.46 miles 15 feet wide, 15.97 miles 18 feet wide, and 3.55 miles of variable width; 8.91 miles of brick roads 10 feet wide, 2.84 miles 15 feet wide, 3.08 miles 18 feet wide, and 3.79 miles of variable width; 4.47 miles of bituminous macadam roads 10 feet wide, 1.00 mile 15 feet wide, and 1.36 miles 18 feet wide; 5.45 miles of waterbound macadam roads 10 feet wide, 4.75 miles 15 feet wide, and 1.67

miles of variable width; 11.45 miles of gravel roads 10 feet wide and 6.58 miles 15 feet wide; 118.00 miles of oiled earth; 65.75 miles of plain earth; 2.34 miles of variable width bituminous macadam resurfaced roads, and 1.51 miles of variable width bituminous concrete roads; and 92 State aid bridges. The total contract price of this work is $1,684,526.00.

Under a section of the State aid law which permits the counties of the State anticipating State aid allotments by issuing bonds or by a special, direct tax, plans and contracts have been approved for 237.8 miles of construction. Under this section of the law, the counties pay the entire first cost of construction and are later repaid one-half the construction cost from the State aid allotments as made. Of this mileage, there were 10.43 miles of asphaltic concrete; 43.74 miles of Portland cement concrete; 2.84 miles of brick; 7.65 miles of bituminous macadam; 58.2 miles of 10 foot brick with 3 foot macadam shoulders on each side and 114.96 miles of 10 foot Portland cement concrete with 3 foot macadam shoulders on each side.

Road Funds

The 1913 legislature appropriated $400,000 for 1914 and $700,000 for 1915 and like amounts were raised by the counties. The 1915 legislature appropriated $1,000,000 for the year beginning July 1, 1915 and $1,000,000 for the year beginning July 1, 1916. Of these amounts, $10,000 was set aside each year for maintenance.

Cook County has issued $2,000,000 in road bonds; Vermilion County has $1,500,000 and Williamson County has raised $270,000 while several other counties have raised amounts varying from $5,000 to $50,000 for construction purposes. There were some forty counties contemplating bond issues for road improvement early in 1917.

[Approved by W. W. Marr, Chief State Highway Engineer.]

INDIANA

State Aid Legislation

The State has no highway department and does not grant aid in any form toward road construction and maintenance.

At the time of going to press the legislature was considering bills creating a State highway department.

Local Road Legislation

Three county commissioners in each county, one commissioner elected in November of each year, have supervision over roads. They are also ex-officio a board of directors for all free gravel, macadam and turn pike roads and shall appoint a county highway superintendent for 2 years. They also appoint superintendents of construction for gravel roads built by assessment of contiguous property.

Boards of township trustees elected in November every four years divide the township into road districts and a supervisor is elected every odd year in December in each road district.

The county highway superintendent shall appoint assistant superintendents not to exceed four for each 100 miles of road. The county highway superintendent shall have general supervision of the maintenance and repair of all county highways, bridges and culverts.

Bond Legislation

County commissioners are authorized, when requested by a petition signed by fifty freeholders, to grade, drain and pave with "stone, gravel or other road paving material" new or existing highways in any township or on the line dividing two or more townships, and to issue 4½ per cent township bonds not to exceed the contract price of the improvements, nor in excess of 4 per cent of the assessed valuation of the townships including bonds already issued. The bonds must be in denominations not less than $50 and payable in semiannual series in not less than ten nor more than twenty years. The bonds are retired by an annual tax levied by the commissioners on all the property of the townships affected. Complete plans and specifications for all improvements are made before the election is ordered by a competent civil engineer and two viewers appointed by the commissioners.

For the same purposes as above, gravel road assessment bonds may be issued by county commissioners when petitioned by a majority of the resident landowners within one mile of the proposed improvement. The bonds are paid off by assessment upon the property in proportion to the benefits derived from the improvement.

For the purchase of toll roads, the county commissioners may issue bonds not exceeding 4 per cent of the payable assessed valuation in annual series for not more than twenty years, and bearing interest not exceeding 6 per cent.

All highway bonds bearing interest not exceeding 4½ per cent are exempt from taxation.

Convict Labor Laws

The managing boards of the State reformatory and State prison may, wherever there is no work for the inmates within the prison, arrange with the county commissioners or township trustees for working the convicts on the roads.

Automobile Registration

The law provides for annual registration with the secretary of State. The schedule of fees is as follows: 25 h.p. or less, $5; 26 to 40 h.p., $8; 41 to 50 h.p., $15; over 50 h.p., $20; electric pleasure vehicles, $3; all commercial vehicles, $5; motor cycles, $2; manufacturers and dealers, $25; chauffeur's license, $2.

The net registration revenue is paid into the State treasury and credited to "a road fund" which shall be apportioned to the several counties on January 1 and July 1, of each year. Fines and forfeitures are paid into the State treasury and credited to the same fund as the registration revenues. (Chapter No. 300, Laws 1913.)

IOWA

State Aid Legislation

By the act of the thirty-fifth general assembly, a State highway commission was created in Iowa with much more power than the former commission. Two members of the commission are appointed by the governor from opposite political parties and the dean of engineering at the Iowa State College is the third member.

The highway commission is charged with the supervision of the road and bridge work of the State. This work is in direct charge of the county and township officers assisted by the county highway engineer. The township officers have charge of construction and maintenance of the township road system which embraces about 85 per cent of the mileage of the county. The county officers build all bridges and culverts and have charge of the county road system made up of those roads not in the township system. The county system, made up of those roads which connect the trading points and the adjoining county systems but not to exceed 15 per cent of the entire mileage of any county are the main traveled roads and constitute a complete network of roads covering the State.

All bridge and culvert work must comply with the highway commission standards. Contracts for single structures costing over $2000 must be approved by the highway commission. All plans for permanent road grading, drainage, and surfacing must be approved by the commission. Standard plans and profiles are made for each mile of road so improved.

Local Road Legislation

Jurisdiction over roads vests in county boards of supervisors and in township trustees, subject to general supervision by the

State highway commission. Road taxes are worked out. A rebate of part of the property road taxes is granted to those complying with the wide-tire law.

Convict Labor Laws

State convicts may be worked at stone quarries, and the crushed stone produced, furnished to counties, townships, or road districts, f.o.b. cars at crushing plant.

The highway commission experimented again in 1916 very satisfactorily with 50 to 75 convict laborers on road, bridge and culvert building. They were paid 22½ cents per hour, out of which they paid the entire expense of their camp and of the single guard in charge of the men. They dressed like ordinary workmen. They were willing and intelligent workmen and good results were secured.

Automobile Registration

The law provides for annual registration with the secretary of State. The schedule of fees is as follows: 20 h.p. or less, $8; each additional h.p. over 20 h.p., $.40 additional; all electric and steam vehicles, $15; motor cycles, $3; manufacturers and dealers, $15.

Five per cent of the gross revenue is set aside in the State treasury as a maintenance fund for the State highway department. Ninety per cent of the gross revenue is apportioned to the several counties of the State for expenditure only for crowning, draining, dragging, graveling or macadamizing public roads outside of incorporated towns or cities.

Highway Officials

State Highway Commission—Prof. A. Marston, J. W. Holden and H. C. Beard. Highway engineer, Thos. H. MacDonald; road engineer, F. R. White; bridge engineer, J. H. Ames.

Progress Report

The total mileage of all the roads in Iowa outside of incorporated towns and villages, is 104,082. The estimated total mileage of roads, including city pavements, improved by hard surfacing is 650. Included under this heading would be classified all roads that have macadam, concrete, or brick surfacing. At this time there are, to our knowledge, only 7 or 8 miles of concrete roads in this State outside the limits of incorporated cities and towns. The estimated amount of 650 miles does not include probably 700 miles of the roads in the State which have been graveled.

There is no law in this State which allows the State to bear a portion of the expense for the construction and maintenance of the highways. At present this work is carried on entirely by the townships and the counties. Under the law enacted by the 35th and 36th general assemblies of this State all of the roads in the State are under the general supervision of the State highway commission. A division is made in each county into townships and county roads. The county constructs and maintains the entire county road system which is composed of not less than10 per cent and not more than 15 per cent of the total mileage of the county. These roads included in the county system have been designated as county roads and the township officials have no authority over them. The remainder of the roads in the townships outside of the limits of incorporated cities and towns are under the supervision of the local township officials, namely, the township trustees and road superintendents.

The thirty-sixth general assembly provided a maintenance fund consisting of 5 per cent of the motor vehicle tax for the general expenses of the State highway commission. This is the only expenditure made by the State towards road improvement at this time. Previous to April 9, 1913, the date when the present law went into effect, the work of the commission was carried on as a department of the State college under an appropriation of $10,000 per year. During 1916 the amount available for the use of the commission was $85,000.

A change was made under the present laws whereby the supervisors of each county were required to appoint a county engineer who has general charge of the road and bridge work throughout the county. Under the present law all of the bridges regardless of size or location excepting those inside the cities and towns, are built and maintained by the county board of supervisors under plans and specifications issued by the commission.

During 1916 the commission has prepared special plans and designs for over $1,500,000 worth of bridges and culvert work. Standard plans have been issued for a number of the general types of highway bridges used by the State as well as standard cross sections for the road work. At present there is a growing sentiment in favor of surfacing the main traveled highways. Many miles of cheaper gravel roads have been built in counties where gravel is readily available. There have been numerous very satisfactory experiments in oiling dirt roads.

Road Funds

Estimated amount of money available for road improvement during 1917, including culverts and bridges: State appropriation for highway commission, $85,000; auto tax distributed by the

State, $1,750,000; township road fund controlled by township trustees, $2,400,000; township drag fund controlled by township trustees, $900,000; county road fund controlled by county supervisors, $3,300,000; county bridge fund controlled by county supervisors, $4,100,000; total, $12,335,000.

The above are all cash taxes. There is in addition roughly $500,000 available from labor taxes.

[Approved by J. W. EICHINGER, Editor State Highway Commission Service Bulletin.]

KANSAS

State Aid Legislation

The State grants no money aid for road improvement, but the office of the State engineer was established at the Kansas State Agricultural College in 1911 for the purpose of giving advice to county road officials throughout the State in connection with the construction and maintenance of roads and bridges. Similar services are also given to county, township and city officials and to citizens of the State on drainage and irrigation work. About $11000 annually is provided from the college appropriations for the maintenance of the State engineer's office. Traveling expenses of engineers, the cost of surveys, and the salaries of inspectors employed on construction work are paid by local authorities receiving the services.

Local Aid Legislation

Jurisdiction of State and county roads is vested in the boards of county commissioners, and of township roads and mail routes in the boards of highway commissioners of the township. The county commissioners of each county of the State may appoint a county engineer to supervise the work on State and county roads and to assist the township officials in improving and maintaining the roads under their jurisdiction. The township highway commissioners must employ one or more overseers outside their own body to supervise the construction and maintenance of mail routes and township roads.

Road Bond Legislation

Upon petition of 60 per cent of the landowners who own at least 50 per cent of the land to be taxed, naming the road, the terminal points of improvement, the kind of improvement, and the number of assessments, not exceeding ten, to be made in payment thereof, the county board shall improve this road if it is found and declared to be of public utility.

The county commissioners are empowered to make contracts. In payment for any work or material, these commissioners shall issue special improvement bonds, bearing interest not exceeding 6 per cent and payable within the time or times mentioned in the petition.

Three-fourths of the cost of the improvement shall be apportioned among the property owners within the radius described in the petition and shall be collected as other taxes. One-fourth shall be charged to the township or townships in which the improvement is made and this amount shall be raised in the same manner as provided by law for raising taxes for all purposes. The county must pay for all engineering and superintendence and for all bridges and culverts costing more than $200 and it may pay any part of the total cost of the improvement that the commissioners may determine. Provided that this act does not apply to the construction or improvement of roads costing less than $500 per mile.

Bridge bonds in any sum not in excess of 1 per cent of the taxable property may be issued by the board of county commissioners of any county, the mayor and council of any city, and the trustee, clerk, and treasurer of any township, upon a majority vote at an election called by a petition signed by two-fifths of the voters of their respective political division.

The bonds shall be in denominations of not less than $100, shall bear interest not exceeding 10 per cent, and shall run for not less than five, nor more than thirty years. No provision is made by statute for issuing county or townships road bonds.

Convict Labor Laws

State convicts may be employed on the roads on payment of $1 per day per man, plus all additional expenses of guarding them. County prisoners may be employed in breaking stone.

Automobile Registration

The law provides for annual registration with the secretary of State. The schedule of fees is as follows: All motor vehicles, $5; motor cycles, $2; dealers shall register one in each class at regular rates.

The net revenue is paid into the county treasury of the county in which collected for expenditure only in maintenance of the designated roads. (Act of March 12, 1913.)

Highway Officials

The State engineer is appointed by the board of administration of the State Agricultural College, Manhattan. W. S. Gearhart, Manhattan, is State engineer.

Progress Report

The total mileage of public highways in Kansas exclusive of the streets of incorporated towns and cities is about 111,052. Approximately 10 per cent of these roads are now in the county systems. County roads are mostly earth roads, but are graded and well maintained. Only about 400 miles of improved roads, consisting of gravel, macadam, brick and concrete, have been built. There are also about 820 miles of sand clay and oiled earth roads in the State.

During the year 1916 the State engineer's office furnished engineering services on $1,000,000 worth of roads and bridges, and $500,000 worth of drainage and irrigation work. Supervision was also provided for the construction of 130 bridges and 10 miles of improved roads.

Road Funds

The estimated expenditure for road purposes, including bridges and culverts, during the year 1916 was $6,000,000. These funds were provided by township and county cash road taxes and automobile registration fees. A cash poll tax of approximately $500,000 was also available but its collection is uncertain.

[Approved by U. S. Office of Public Roads and Rural Engineering.]

KENTUCKY

State Aid Legislation

By an act passed in March, 1912, the governor was required to appoint on July 1, 1912, and every four years thereafter a State commissioner of public roads, who shall be a graduate in civil engineering from some reputable university or some technical college and have had at least five years' experience in civil engineering. The expenditures chargeable to the State road fund were limited to not to exceed $25,000 per annum. The commissioner is authorized to collect and disseminate information, furnish plans, specifications, and estimates of cost of bridges and roads, but it is not obligatory on the part of local officials to accept such plans and specifications, but they must be kept on file in the office of the county road engineer, as are the plans, specifications, and actual cost. He is also required to hold an examination for the appointment of county engineers, and such county engineers shall, upon order of the State commissioner, cause all roads within their counties to be measured and shall make report to the said commissioner.

The General Assembly of 1914 passed a bill which levied a State tax of 5 cents on the $100 of taxable wealth, which is to constitute a State road fund to be redistributed to the counties applying for aid to the extent of one-half the cost of construction or reconstruction of public roads. No county to receive in any one year more than 2 per cent of the total fund.

Also another bill was passed, making roads connecting the county seats of adjoining counties on the most direct and practical route, public State highways, to be the first to receive State aid.

Road Bond Legislation

On the petition of 150 voters and freeholders of a county, the county court shall call an election to determine whether bonds of the county shall be issued in an amount not to exceed 5 per cent of the taxable valuation of the county. If two-thirds of the legal voters voting shall favor the issuance of bonds, the fiscal court may issue them, to bear not exceeding 5 per cent interest, to run not less than five nor more than thirty years, and to be sold for not less than par. The fiscal court shall levy an annual tax of not to exceed 20 cents on each $100 valuation of taxable property in the county, to pay the interest on such bonds, and to create a sinking fund for their redemption at maturity. Sinking fund accumulations may be loaned by the fiscal court on first mortgage real estate security, on the basis of 50 per cent of its value.

Any county which issues bonds and expends the proceeds thereof for building public roads, under the direction of the commissioner of public roads, in an amount greater than the amount which said county may be able to secure by apportionment from the State road fund for that year, shall be entitled to receive from the State road fund in subsequent years such further amounts or apportionments as will make the total amount ultimately received from said fund equal to one-half the amount so expended by said county.

Convict Labor Laws

Prisoners sentenced to work at hard labor may be placed in the work-house, if there be one in the county, or at work upon the public works, or roads, of the county, or upon the public works of any city or town in the county. The place of working such prisoners shall be determined by the county judge, giving preference to work on roads of the county whenever the weather will permit. When placed upon the public works of any city or town, such city or town shall provide and pay for food, lodging, and guarding; and when placed on the county roads, such cost shall be paid out of the road funds of the county. The county judge is authorized to appoint a manager for each crew of prisoners, who shall also act as guard. No crew shall consist of less than three prisoners, and not more than one man shall be paid to guard and manage less than ten prisoners. The county or fiscal court shall have power to prescribe regulations for the government of prisoners and those in charge of them. All prisoners placed at hard labor shall be permitted to satisfy their fines and costs with such labor, at the rate of $1 per day.

The State may employ State convicts outside of the walls of the penitentiary in road or bridge work, or in the preparation of materials therefor.

Local Road Legislation

The roads are under the county fiscal courts.

There is created in the several counties of the State the office of county road engineer, who is to be appointed by the county judge, by and with the consent of the fiscal court, for a term of two years. Such county road engineer shall be either a reputable civil engineer or a man who has had practical experience as a road supervisor or builder for two years and who shall have passed a creditable examination by the State commissioner of public roads or one of his representatives. (Acts of 1914, Chap. 80, Sec. 39.)

The county road engineer may be removed at any time by the county judge upon his own volition for incompetence, malfeasance or misfeasance in office, upon written charges, after a hearing of which 10 days' notice shall be given by serving a copy of such charges upon such county road engineer. (Acts 1914, Chap. 80, Sec. 40.)

Automobile Registration

The law provides for annual registration with the secretary of State. The schedule of fees is as follows: Less than 25 h.p., $6; 26 to 49 h.p., $11; 50 h.p. and over, $20; manufacturers and dealers, one vehicle in each class, at regular rates.

Registration revenues are paid into the State treasury for the benefit of the State road fund. (Act of March 14, 1910.)

Highway Officials

State commissioner of public roads, Rodman Wiley, Frankfort.

Progress Report

The department furnishes plans, specifications and estimates for all bridges over $500 in value. It furnishes specifications for all new roads and the same for all reconstruction when requested by the fiscal courts. The department also keeps up a continuous campaign along educational lines, by mailing bulletins of road information, by displaying road models at the State fair and some of the larger county fairs, by holding road meetings over the State and by furnishing speakers for road meetings in the various counties of the State. Since the organization of the department plans, specifications and estimates for about 757 bridges have been made, surveys for about 1600 miles of new road have been made, about 4000 miles of old road has been inspected and advice furnished; 1400 miles of road have been constructed under the direct supervision of the department.

Road Funds

In 1916, the State-aid fund will probably be $712,000, the same amount will be raised by counties for State-aid roads, and about $3,000,000 in bonds will probably be issued for roads. To date 31 counties have voted bonds amounting to $5,755,000.

[Approved by RODMAN WILEY, State Commissioner of Public Roads.]

LOUISIANA

State Aid Legislation

The board of State engineers is authorized to appoint a State highway engineer, who holds office until removed for cause by the board. He is required to be a competent civil engineer, experienced in highway work. The board is authorized to appoint assistants and clerks and provide offices; to hold meetings in its discretion for considering the general policy of the department and receive the annual report of the State highway engineer. The board acts in all matters concerning recommendations, estimates, etc., to be submitted to the governor.

The State highway engineer is required to make a general highway plan of the State, collect statistics, establish standards for construction and maintenance, have supervision over construction and maintenance of State highways on which State aid has been granted, subject to the approval of the board of State engineers. He or his assistants must make all surveys, plans, specifications, and estimates and select material for such State highways. He awards contracts, but may reject any and all bids and conduct the work with his own force. He is authorized, with the approval of the board of State engineers, to purchase, for the State, road machinery, draft animals, and supplies, and loan such equipment to the parishes. Upon completion of contract for State highways the State highway engineer certifies to the State treasurer and the president of the police jury the portion to be paid by the State and parish respectively.

The State highway engineer is required to keep all roads improved as State highways in repair, the total cost to be paid by the State and the parish to reimburse the State in the same manner as for construction. He is required to organize a system of repair whereby all roads may be in good condition at all times.

The initiative in obtaining State aid rests with the police juries of the respective parishes. They make application to the State highway engineer for State aid in the improvement of main traveled roads, and the said State highway engineer must take up such applications as far as practicable in the order of their receipt, provided the parishes have raised their portion of the cost of such improvement.

In order to provide a State aid fund a general property tax of one-fourth of 1 mill, is placed in a fund known as the State highway fund. This fund is apportioned by the State highway engineer with the approval of the board of State engineers. From 10 to 50 per cent of the cost of State aid roads is apportioned to the State and 50 to 90 per cent to the parish.

Local Road Legislation

The State is divided into parishes and the roads in each parish are under its police jury. The police jury may divide the parish into road or sub-road districts, in which case the roads are under the control of a board of supervisors.

Road Bond Legislation

Municipal corporations, drainage districts, or parishes may issue bonds for the purpose of improving the roads therein. Before these bonds are issued, the question shall be submitted to an election and a majority in number and in the amount of property valuation of the actual votes cast shall be necessary to carry the election. Bonds shall not be issued for a greater amount than 10 per cent of the assessed valuation, shall bear not exceeding 5 per cent interest, and shall run not to exceed forty years. A sinking fund shall be provided to redeem these bonds at maturity and an annual tax imposed to create this sinking fund and pay the interest on the bonds annually. Such bonds shall be sold for not less than par, and the proceeds thereof shall not be used for any other purpose than that for which they are issued.

Police juries of the several parishes are authorized to divide their respective parishes into road or sub-road districts, and the governing authorities of said districts shall have the right to issue bonds, in accordance with the general laws of the State authorizing the issuance of road bonds, to provide for the construction of the public roads therein.

Convict Labor Laws

Under the provisions of the law, the highway department, board of State engineers, has the right and power, when available, to employ state convicts for highway work. Under this system of State aid, the board of control of the State Penitentiary furnishes the convict labor, retaining such rights over them as relate to their guardianship, personal care, and enforcement of physical labor. The highway department, board of State engineers, supervises all work relative to construction, makes all surveys and locations, and outlines and puts into execution all details relative to the building of highways under this system. The police jury of each respective parish furnishes all funds for the maintenance, guarding and working of the convicts, all materials required in the construction work, and all required rights-of-way.

Automobile Registration

Annual registration of motor vehicles with the secretary of state is required, the fee being 25 cents per horse power with a minimum fee of $5. A flat fee of $2 is required for each motor cycle and $7.50 for each motor truck. The proceeds from the registration of motor vehicles is to be paid to the various parishes from which collected and apply to the construction and maintenance of roads. Non-residents are exempt if like exemption is granted residents of Louisiana. The act was submitted to a general election in 1914 and ratified and became effective January 1, 1915.

Highway Officials

The board of State engineers of Louisiana, of which the highway department is a branch, is composed of the following members: F. M. Kerr, Chief State engineer, Gervais Lombard, J. W. Monget, Marshall P. Robertson, John Klorer.

The officers of the highway department of the board of State engineers are: F. M. Kerr, chief State engineer, and president of the board of state engineers; Duncan Buie, State highway engineer; W. F. Cooper, assistant State highway engineer; Chas F. Wood, secretary, New Orleans.

Progress Report

During 1916, the highway department, board of State engineers, extended State aid to 15 parishes for the construction of 19 highway projects aggregating 195.94 miles, of which 14.00 are shell roads, 145.14 miles gravel, and 36.80 improved earth. The estimated cost of construction is $600,000, the State contributing approximately $130,000, and the parishes the remainder.

State convicts were not employed during 1916 in the construction of State-aid projects.

Road Funds

The highway department, board of State engineers, will have available during 1917 approximately $200,000, including State and federal funds, for distribution among parishes applying for State and federal aid. The department will probably have under construction during 1917 approximately 250 miles of State-aid projects to cost about $750,000.

Bonds are being issued and special taxes voted in nearly all of the parishes.

Total expenditures for State-aid roads up to December 31, 1916: State funds $531,501.88; parish funds, $901,056.24; total, $1,432,558.12, exclusive of cost of gravel furnished by parishes for gravel roads. These amounts are supplemented by labor of State convicts employed during 1911, 1912 and 1913.

[Approved by CHARLES F. WOOD, Secretary Highway Department.]

MAINE

State Aid Legislation

Under an act passed in 1913 "the governor with the advice and consent of the council shall appoint a State highway commission consisting of three members; one to serve three years, one to serve two years and one to serve one year.

"The commission shall select, and with the approval of the governor and council appoint a chief engineer, upon terms to be fixed from time to time by the commission, subject to the approval of the governor and council."

He shall under the direction of and control of the commission have general charge of the office, the records and all construction and maintenance work, and may with the approval of the commission employ necessary clerical assistance. The engineer may with the approval of the commission employ such other engineers, supervisors, assistants and help as he may deem necessary.

The commission shall lay out, construct and maintain a system of State and State aid highways. The State highways to be constructed wholly by the State from the bond issue. The State aid highways to be constructed by the State and municipalities jointly. Both classes of highways to be maintained under the direction of the commission, the cost to be borne jointly by the State and municipalities. The charge against the municipalities for maintenance of State highways shall be $60 per mile per annum; for State aid highways, the charge shall be one-half the actual expense but not to exceed $30 per mile per annum.

The commission have full power in the letting of all contracts for the construction of all State and State aid highways. The commission may make contracts with towns for construction of State aid roads without advertising for bids.

Towns may make the following appropriations and apply for State aid:

Towns having a valuation of $200,000 or less may appropriate any amount, not exceeding $300; towns having a valuation of over $200,000 and not over $800,000 may appropriate any amount not exceeding $533; towns having a valuation of over $800,000 and not over $1,000,000 may appropriate an amount not exceeding $600; and towns having a valuation of over $1,000,000 and not over $3,000,000 may appropriate in addition to the sum of $600 an additional sum of $66 for each $200,000 or fraction thereof valuation in excess of $1,000,000; towns having a valuation of over $3,000,000 and not over $4,000,000 may appropriate, not exceeding $1333, and towns having a valuation of $4,000,000 may appropriate in addition to the sum of $1333 an additional sum not exceeding $133 for each additional $1,000,000 of additional valuation.

The commission from the funds for State aid construction shall to each town which has conformed to the provisions of the act, for each dollar so appropriated, apportion the following amounts:

To each town having a valuation of $200,000 or less, $2 for each dollar appropriated by said town; to each town having a valuation over $200,000 and not over $1,000,000 $1 for each $1 appropriated by said town; to each town having a valuation of over $1,000,000 and not over $1,200,000 92 cents for each $1 appropriated by said town; to each town having a valuation over $1,200,000 and not over $1,400,000, 85 cents for each $1 appropriated by said town; to each town having a valuation over $1,400,000 and not over $1,600,000, 80 cents for each $1 appropriated by said town; and to each town having a valuation over $1,600,000, 75 cents for each $1 so appropriated by said town. The money appropriated by towns applying for State aid with the amount apportioned by the commission shall constitute a joint fund for the construction and improvement of the State aid highways in such towns.

After the year 1913, between the 15th day of July and the 15th day of August in each year, municipal officers shall prepare and file with the commission, suggestions for the improvement during the next calendar year of State aid highways located in each town accompanied by plans so far as practicable, setting forth the location of the highway and the nature of the improvement desired. The commission shall examine and report thereon with its recommendations to the muncipal officers on or before the 20th day of February following. Such reports shall be submitted to the voters of such towns at the next regular meeting.

To provide funds for the construction of State aid highways there shall be appropriated for the year 1913 the sum of $250,000 and annually thereafter there shall be appropriated the sum of $300,000. To provide for the administration of the office and duties of the commission and for all expenditures, salaries and expenses incident thereto, and for the maintenance of all State and State aid highways there shall be appropriated the sum of $50,000 annually. For the construction of the State roads the treasurer of State is authorized under the direction of the governor and council to issue from time to time serial coupon bonds, not exceeding $2,000,000 in amount outstanding at any one time, payable at the State treasury within forty-one years from date of issue; the interest on the bond issue and retirement of bonds to be provided for from the automobile license fees. Not more than $500,000 of bonds shall be issued in any one year.

The fund for maintenance and administration is augmented each year by the balance remaining on the 31st of December in the appropriation for State aid highways; that is, so much of the State's appropriation for this purpose as has not been apportioned to municipalities on account of State aid is automatically carried into the fund for administration and maintenance for the succeeding year. This fund is further augmented by the balance remaining in the fund created by the licensing of automobiles after providing for the payment of interest on the bonds issued and a sinking fund for the retirement of bonds.

Chapter 272, laws of 1915, placed the maintenance of all the principal thoroughfares in the State, both improved and unimproved, under the direction of the State highway commission, the work to be done at the joint expense of the State and the towns.

Various amendments to the State highway law were before the legislature when this book went to press.

Local Road Legislation

Jurisdiction over roads vests in the boards of county commissioners in the case of county roads and all roads in unincorporated towns; all other local roads are under the boards of selectmen of the towns.

Convict Labor Laws

Upon written application from county or municipal authorities the board of prison inspectors may direct that jail prisoners be worked on county roads.

Automobile Registration

The law provides for annual registration with the secretary of State. The schedule of fees is as follows: 20 h.p. or less, $5; 21 to 35 h.p., $10; over 35 h.p., $15; motor trucks and commercial automobiles, $10; traction engines, $10; motor cycles, $3; operators, including owners, $2.

Registration revenue is paid into the State treasury and credited to a fund for the repair, maintenance and construction of State highways. (Chapter No. 162, Laws 1911.)

Highway Officials

State Highway Commission, Augusta.—Philip J. Deering, chairman; William M. Ayer, Frank A. Peabody; Paul D. Sargent, chief engineer.

Progress Report

During 1916, 157.056 miles of State-aid roads were constructed at a cost of $552,371.62, and 3.143 miles under special resolutions at a total cost of $7,962.21. There were 69.81 miles of State highways built at a cost of $466,998.33.

During the year a patrol system of maintenance was established, with 373 patrolmen in 423 towns on a total of 3,373 miles of road. This work cost the State and towns $275,000. The roads thus maintained comprised about 200 miles of improved State highways, 1,000 miles of improved State-aid roads, and the balance unimproved roads in these two systems. In addition about 100 towns maintained their improved State-aid roads under an agreement by which the State paid half the cost up to $60 per mile.

Road Funds

The proceeds of a $200,000 bond issue will be available in 1917 and the legislature is expected to authorize a 1-mill tax furnishing $321,000 for constructing State highways and $200,000 for constructing State-aid highways, supplementing a direct appropriation of $300,000. In addition there will be $146,000 of federal aid funds for use on State highways and $300,000 of town appropriations for State-aid highways. The automobile license fees are expected to net about $350,000 for maintenance and about

$135,000 for that purpose is expected from cities and towns. This makes a total fund of about $1,742,000 for road purposes. The legislature is discussing a referendum on a $4,000,000 bond issue, but if passed by the legislature and approved by popular vote the money will not be available before 1918.

[Approved by Paul S. Sargent, Chief Engineer, State Highway Commission.]

MARYLAND

State and State Aid Legislation

The State roads commission consisting of three members appointed by the governor has direct control over the construction and maintenance of a system of main highways through all the counties in the State, the cost of such construction and maintenance to be borne entirely by the State. The commission also has authority to approve applications for State aid on roads not included in the trunk-line system, and when such applications are approved the plans and specifications are prepared by the State, the contract awarded by the counties subject to approval of the State, and the performance of the contract supervised by the State.

The cost of State aid roads is shared equally by the State and counties. The allotment of State funds to the counties is based upon road mileage. After the construction of a State aid road its maintenance devolves upon the State authorities.

A system of trunk-line roads, built and maintained entirely at the expense of the State, was authorized by the legislature in 1908, and a State bond issue of $5,000,000 was authorized for this purpose. An additional bond issue of $1,000,000 was authorized by the legislature in 1910, in 1912, a bond issue of $3,170,000 was authorized, $6,600,000 in 1914, and $2,700,000 in 1916. The trunk-line system is selected entirely by the State roads commission and every stage of the work is completely under the control of the commission. A chief engineer selected by the commission is the executive officer and active head of the work. The funds for State aid roads as distinguished from State roads are provided by direct appropriation. The legislature in 1912 provided that an annual State tax of 1 cent on each $100 should be levied to provide a maintenance fund for State highways.

Local Road Legislation

Jurisdiction over county roads vests in elected boards of county commissioners who may employ competent civil engineers for the construction and maintenance of bridges and roads.

Convict Labor Laws

For the purpose of building and constructing or maintaining any road, bridges or highways under the provisions of this act (State highway act of 1910) or for the purpose of working any stone quarry operated by the State roads commission, the said commission is authorized to make request of the directors of the Maryland House of Correction for as many inmates thereof as may be necessary for said purpose, and the said directors are directed to furnish same with a sufficient number of guards for their safe-keeping of the prisoners while so employed.

The use of convicts on public roads in certain counties is also authorized by law.

Automobile Registration

The annual registration fees are paid to the commissioner of motor vehicles and are 50 cents per horse power for motor vehicles with pneumatic tires, with a minimum of $5; $8 for a motor vehicle with solid tires and a rated capacity not exceeding 1 ton, plus $6 for each additional ton capacity; $5 for trailers after any motor vehicles; $3 for motorcycles; $20 for two sets of dealers' tags and $10 for each additional set, available on all cars of a dealer not used for hire; $8 for four tags for motorcycles and $2 for each additional tag; $1 per horse power for motor vehicles transporting persons for hire, other than vehicles operating on fixed schedules; motor vehicles operating on schedule for passenger service, fee per passenger seat per mile of total annual scheduled mileage, $\frac{1}{20}$ cent for vehicles under 3000 pounds, $\frac{1}{18}$ cent for vehicles weighing 3000 to 7000 pounds, $\frac{1}{14}$ cent for vehicles weighing over 7000 pounds; fee for freight motor vehicles operating on schedule, per ton capacity per mile of total annual scheduled mileage, $\frac{1}{12}$ cent for trucks weighing less than 3 tons loaded, $\frac{1}{10}$ cent for trucks weighing 3 to 6 tons, $\frac{1}{8}$ cent for trucks weighing over 6 tons. Operator's license, $2.

One-fifth of the net registration revenue is apportioned to the city of Baltimore for use on its roads and streets and the remainder shall be expended for oiling, repair and maintenance of the modern State and county roads. Fines and forfeitures are paid into the State treasury for the same use as the registration revenues.

The commissioner of motor vehicles is authorized to expend from the receipts of his office each year not exceeding $1000 for the erection of sign posts for the direction of and warning of danger to travelers. The said commissioner is also authorized to employ deputies equipped with motor cycles to enforce the motor vehicle and traffic laws of the State and pay for same in an amount not exceeding $5000 per year from the receipts of his office.

No motor vehicle in excess of 90 inches width, and no traction engine in excess of 100 inches width shall be operated on highways of State; or in which the limit of load is over 650 pounds per inch in width of tire without special permit from State roads commission, if a State road, or proper local authorities of other road. No motor vehicle of which the weight of truck and load exceeds 14 tons shall be operated on any highway.

Highway Officials

Chairman, Frank H. Zouck; G. Clinton Uhl, John F. Mudd.

Assistant to chairman, John E. George; chief engineer, Henry G. Shirley; secretary, Clyde H. Wilson; counsel, Albert C. Ritchie, attorney general.

Progress Report

In 1916, 118 miles of new State roads were begun, and 20 miles completed, 500 miles were oiled and 1049 miles were maintained. About 1000 miles of the State trunk roads were completed at the end of the year. On State aid work, 84 miles of new road were started and 20 miles finished.

Road Funds

It is expected that the legislature will make appropriation for State road work in 1918. The State-aid funds furnished jointly by the State and the counties are expected to yield at least $500,000, and the counties will probably spend about $2,000,000 on their roads.

[Approved by HENRY G. SHIRLEY, Chief Engineer, State Roads Commission.]

MASSACHUSETTS

State Aid Legislation

A State highway commission consisting of three members appointed by the governor for a term of three years, one term expiring each year, has control over the construction and maintenance of roads, partially or wholly paid for by the State.

The duties of the commission relate to roads and automobiles. Its duties so far as they relate to roads are: (*a*) The collection of statistics as to road materials and road conditions in the State, the making of maps, the giving of advice to local road authorities, etc.; (*b*) the laying out and construction of State highways, the improvement of certain town roads, and the supervision of maintenance of State highways.

The State highways are such as are designated by the commission upon petition of the city government, the board of selectmen, or the county commissioners. As soon as a highway has been thus designated, it passes under complete jurisdiction of the State highway commission, which has control not only of construction and maintenance but also of the location of water and gas mains, poles or other structures, the planting or cutting down of trees on the right of way, etc.

The cost of constructing State highways is borne as follows: 75 per cent by the State and 25 per cent by the county in which the highway is located, the State paying the entire cost on the first instance and collecting as a refund the 25 per cent from the county.

In order to aid the small towns, 15 per cent of the amount appropriated annually for State highway construction may be expended as follows: 5 per cent in towns of less than $1,000,000 valuation, upon petition, the town making no contribution; 5 per cent in towns of less than $1,000,000 valuation, the towns contributing an equal amount; and 5 per cent in towns of more than $1,000,000 valuation, the towns contributing an equal amount, which amount must be in excess of its average annual appropriation for roads for the last five years.

This has been amended by the acts of 1913, chapter 774, which provides that when any road has been constructed or improved, in whole or in part, with money furnished by the commonwealth, and is not laid out as a State highway, the city, town, or county shall at all times keep it in good repair and condition. The commission shall from time to time notify the authorities in charge of the road whenever it is not so kept in condition, and shall specify what repairs or improvements are necessary, and said authorities shall forthwith proceed to make the specified repairs and improvements. If not made within sixty days (unless further time is allowed) the commission may do the specified work and pay for the same from any money available for the maintenance of State highways or from the part of the motor vehicle fees' fund available for work on through routes in the towns (20 per cent of the net). The amount of such expenditures shall be collected back in the manner in which the expense of repairs on State highways is collected (see above). The money collected to be available for use for the same purposes for which the money so expended was available, or for the repair and maintenance of State highways: but in towns of under $1,000,000 valuation not more than $50 a mile a year; in towns with a valuation of over $1,000,000 and under $2,000,000 not more than $100 a mile a year, and in towns with over $2,000,000 valuation not more than $200 a mile a year shall be collected in any one year; but any balance due may be collected in succeeding years, the maximum collection in any one year being as above stated. The commission may upon petition exempt any town from the whole or any part of such payment if in its judgment said payment would prove to be an undue burden.

The State highway commission maintains the State highways at the expense of the State in the first instance, and the counties are required to repay to the State 25 per cent of the amount expended by the State for maintenance. This has been amended by the acts of 1913, chapter 773, so that not exceeding $50 a mile a year is collected back from towns of under $1,000,000 valuation; not exceeding $100 a mile a year from towns whose valuation is from $1,000,000 to $2,000,000; not exceeding $200 a mile a year from towns whose valuation is from $2,000,000 to $5,000,000 and in cities and towns of a valuation of over $5,000,000, one-half said expenditures, not exceeding $2000 a mile in the aggregate, and not exceeding $500 a mile in any one year, shall be made a part of the State tax and collected, and any balance due may be made a part of the State tax for the succeeding three years. The amount collected shall be credited to the appropriation for State highways, to be used again by the commission.

The State road revenues are derived from State bond issues, usually authorized for five years, one-fifth of the amount authorized to be issued each year during the five-year period. The present bond issue is at the rate of $1,000,000 per annum. Of the automobile fees and fines, after deducting the expense of administering the automobile department, 80 per cent is applied to the maintenance of State highways, and 20 per cent is spent on through routes in the towns. The net fees, fines, etc., now amount to from $1,500,000 to $1,600,000 per annum. In addition, the legislature makes direct appropriations from time to time to meet special expenses and additonal maintenance cost. The towns in 1916 appropriated over $391,000 of their own money to go with the $150,000 State aid money and the $250,000 motor vehicle fee money appropriated by the Commission for road improvement in the towns. The counties appropriated $123,000 to go with this money, making about $900,000 in all available for the improvement of these secondary roads. Work was done in 206 towns with these two funds in addition to the building of State highways.

As indicating the manner in which the law is carried out in relation to road construction by the State highway commission, it may be stated that contracts are awarded by the commission to the city or town in which the highway is to be laid out, if prices are satisfactory to the commission and if the contract is acceptable to the local authorities. The work is then done by the local authorities under the direction of the commission and its engineers. The contracts for State highway construction are usually based on given unit prices for each item of work, while the small town contracts are on the lump-sum basis. If the local authorities do not take the contract, bids are advertised for and awarded in the usual way.

The organization of the commission is as follows: A central office at Boston with three commissioners, a secretary, the various assistants in the highway department, the motor-vehicle department, and a chief engineer. The State is divided into four divisions each in charge of a division engineer, who has the necessary assistants and resident engineers, who are employed directly on the work. State issues bonds for road construction.

Local Road Legislation

The local roads are under the boards of selectmen of the towns or under a superintendent of streets, or under district road surveyors, as the town, from time to time determine. The county commissioners may, upon petition, lay out new roads or make specific improvements, and may direct towns and cities to make such improvements.

Convict Labor Law

By Chapter 633 of the acts of 1913 there was a provision for using prisoners in improving waste and unused land. In 1914 this act was amended so that the county commissioners could make arrangements with the officials of any city or town or with the highway commission to work prisoners on any highway, the prisoners to be in the custody of the sheriff of the county. When land that is not the property of the county, or is a highway, is so improved, the owners thereof or those having in charge the highway shall pay to the county such sums as may be agreed upon between the county commissioners, sheriff, and the other parties in interest, for the labor of any prisoners employed thereon.

There were 1½ miles of macadam road built in 1915 under the provisions of this act, solely by the labor of prisoners, and 1¼ miles were built in 1916, undoubtedly more will be built in the near future.

Civil Service Laws Applicable to Road Officials

In all work of any branch of the service of the commonwealth, or of any city or town therein, citizens of the commonwealth shall be given preference. The civil service commission shall not place upon its list any person not a citizen of the United

States. If an appointing officer, by reason of the non-existence of an eligible list, shall appoint under provisional authority from the civil service commission a person not a citizen of the United States, he shall discharge the person so appointed and appoint from the eligible list, whenever the civil service commission shall have established a list of the proper class. When the attention of the civil service is called, by a complaint on the part of the citizens, to the employment of a non-citizen when there is an eligible list, the commission shall take steps to enforce the dismissal of such non-citizen and make an appointment in his stead from the suitable eligible list. A penalty is provided for appointing officers continuing the employment of a non-citizen for a period of ten days after having due notice of such unlawful employment.

Automobile Registration

The law provides for annual registration with the State highway commission. The registration fees are as follows: Less than 20 h.p., $5; 20 to 29 h.p., $10; 30 to 39 h.p., $15; 40 to 49 h.p., $20; 50 h.p. and over, $25; motor cycles, $2; all commercial automobiles and trucks, $5 for each one of one ton capacity and $3 additional for each additional ton or fraction thereof; dealers and manufacturers, $25; and $5 for each additonal car over five demonstrated on the roads; dealers and manufacturers motor cycles only, $10; operators, including owners, $2, renewal fee $1 a year. Non-residents are exempt to such an extent as the State of their residence grants exemption to the residents of the State of Massachusetts. The term "non-residents" is defined to be those who have no regular place of abode or business in the State of Massachusetts for a period of more than 30 days in the calendar year.

The net registration revenue shall be expended under the direction of the State highway commission for maintenance of State highways, provided that an amount not exceeding twenty per cent of such reveune may be expended by the Commission for the repair, improvement and construction of local roads used as through routes. All fines and forfeitures are credited to the same fund as registration receipts.

Highway Officials

State Highway Commission, Boston.—William D. Sohier, chairman; Frank D. Kemp, James W. Synan, Frank I. Bieler, secretary; Arthur W. Dean, chief engineer.

Progress Report

About 54 miles of State highway were laid out during 1916, and work was completed on over 48 miles that were laid out in 1915. The commissioners have constructed in all under the "small town" act over 527 miles, and with the money available from the motor vehicle fees for use in the towns nearly 270 miles of road have been constructed and improved, and from special appropriations over 76 miles have been constructed. During 1916 over 187 miles of road were constructed and improved by the Commission with the money available from all sources, including the $391,000 contributed by the towns and the $123,000 contributed by the counties. The commission has been doing work in 341 cities and towns out of 354 in the State, under the "small town" act, State highway, motor vehicle fees, etc.

Of State highways constructed in 1916, 6.46 miles were bituminous macadam, 1.71 miles waterbound macadam which will be covered with bituminous binder, 0.75 mile gravel, 11.48 miles sand and oil, 3.51 miles of concrete, 2.16 miles of bituminous gravel, 4.53 miles of gravel with light oil.

There were 139.09 miles of road completed in 1916 from State highway, State aid, and special funds. Of this 11.22 miles were waterbound macadam, 46.25 miles gravel, 14.95 miles sand bound with oil and asphalt, 18.61 miles macadam with bituminous binder incorporated in the top course, 15.04 miles waterbound macadam with an oil surface applied, 3.93 miles gravel with the top surface bound with bituminous binder, 5.17 miles cement concrete, 10.93 miles gravel with an oil surface applied, 0.82 mile broken stone and tar mix, 0.38 mile Warrenite, 0.06 mile granite block on a concrete foundation, and 8.25 miles dirt roads surfaced with the best available material.

The Commission has continued to fill in the gaps on the through roads as rapidly as possible, and almost all cities and town have coöperated so that a number of the main through lines will soon be completed.

During 1916 bituminous materials were used on practically all of the 1155 miles of State highway. Over 51½ miles of the older roads were resurfaced and 64 miles of the older roads were also widened from 15 to 18 feet with 21 feet on curves. About 4,000,000 gallons of bituminous materials were used.

The total expenditures for road purposes by the cities and towns were $12,032,670. This includes the money which was expended by the cities and towns in connection with the work done by the State commission, but does not include the money expended by the counties. The mileage and classification of improved roads in the State at the close of 1916 were as follows: gravel roads, 7956 miles; plain macadam roads, 2074 miles; bituminous macadam roads, 565 miles; macadam with oil or tar coat, 1375 miles; pavement, 467 miles; dirt roads, 10594 miles; a total of 23,031 miles. No doubt more roads were improved by the cities and towns but the data are not available.

Road Funds

The yearly appropriation by the cities and towns in Massachusetts for highways and bridges was $12,032,000. The cities and towns have also an excise and franchise tax available from the street railway companies, amounting to $1,633,919 in 1914,making a total of about $13,665,919. These taxes were collected for 1914, and apply approximately to 1915 and 1916. These expenditures were those made by the cities and towns but did not include the expenditures of the State for State highways, State aid roads, etc.

The State highway commission expended in 1916 for new construction, including State highways and "small town" work and the work done with money obtainable from the motor vehicle fees, $777,910.10. It spent under special acts $504,089.69 on several routes, making $1,281,999.79. It had available for construction under special acts of the legislature $468,662.57, making a total of $1,750,662.36.

It also expended for the maintenance of highways, bridges, etc., $1,332,024.27; for general office expenses, salaries of the commissioners, etc., $74,679.38. The automobile department, which has to investigate automobile accidents, care for the registration of cars and the issuing of number plates, etc., expended $153,919.77. The total expenditure of the department was $2,871,923.01. The total expenditures for highways by the cities and towns and the State amounted to $14,594,420, this including the $123,000 spent by the counties.

In 1917 the State highway department has available from the loan fund for State highway work and "small town" work, $1,000,000; for work in the towns under the motor vehicle fees act, about $294,000, and for the maintenance of bridges $27,500; for the repair and maintenance of State highways from the tax levy, probably $415,000, and from the motor vehicle fee fund about $1,200,000. There is also available from certain special acts of the legislature requiring the construction of particular roads, an unexpended balance of $513,000; under a special act for improving 17 different routes in 38 towns and one city, $500,000 or more is available this year for the improvement of 163 miles of road; also $38,000 for tree work and the maintenace of road machinery; making a total to be expended by this department in 1917 of $3,987,500. To this should be added from $300,000 to $400,000 that will undoubtedly be appropriated by the towns and cities to be used with the State funds; the counties will also appropriate from $100,000 to $200,000 to be expended.

There are a large number of propositions relating to particular roads now pending before the legislature, some of which may become a law and additional appropriations may be made for the purpose of constructing particular roads.

[Approved by Col. Wm. D. Sohier, Chairman, State Highway Commission.]

MICHIGAN

State Aid Legislation

The law provides that in 1913 and every four years thereafter a State highway commissioner shall be nominated and elected by the people at the same time and in the same manner as the justices of the supreme court. He is required to be a citizen of the State and may appoint a deputy, who shall be a civil engineer skilled in road building, and such other assistants as may be necessary. His duties are to give instruction in road and bridge construction and maintenance, to collect statistics, and distribute State-reward funds or any funds given to the State for such purposes by the United States government or by individuals. He is required to give expert advice to the local authorities and is required to make a map of every township in the State showing the roads and their condition and the location, kind, and quantity of road materials, etc. His decision is final as to whether a road merits State reward, and he may withhold any portion of the reward until the road has been thoroughly tested.

Whenever any township board or board of county commisssioner or good roads district commissioners have made arrangements to improve a mile or more of public road by constructing a sand-clay, gravel, stone-gravel, gravel-stone, macadam, concrete or brick road and ask for an allotment of State reward, and file with the State highway department a profile of the highway to be improved, and make application for plans and general specifications, the State highway commissioner shall furnish the plans and specifications and allot the funds from the State treasury as the State reward if, after completion, he finds the road to be up to the required standard. Each surveyed township is entitled to receive State reward on no less than 1 or more than 4 miles of road in any one fiscal year. The reward is allotted as follows:

a. Each mile of well graded road, with grade not exceeding 6 per cent, except where found impracticable and a steeper grade is recommended after examination by the State highway commissioner, width not less than 20 feet between side ditches, properly drained, with travel track not less than 9 feet, made of a mixture of sand and clay, shall merit if approved by the State highway commissioner, a reward of $250 per mile, and pro rata for extra miles, with an extra $25 for each additional foot in width of metaled surface in excess of 9 feet up to and including 16 feet.

b. Every mile of well graded road having not to exceed 6 per cent grade, except where found impracticable and a steeper grade is recommended after examination by the State highway commissioner, width not less than 20 feet between ditches, well drained, travel track not less than 9 feet, surface not less than 8 inches compacted gravel applied in not less than two courses, each rolled separately, shall merit, if approved by the State highway commissioner, a reward of $500 per mile, with an extra $50 per mile for each additional foot in width of metaled surface in excess of 9 feet up to and including 16 feet.

c. Every mile of well graded road having not to exceed 6 per cent grade, with not less than 20 feet between ditches, well drained, travel track not less than 9 feet and having a foundation not less than 4 inches of crushed stone, slag or other material compacted, and top course of layer of gravel not less than 3 inches, shall merit, if approved by the State highway commissioner, a reward of $750 per mile, with an extra $75 for each additional foot in width of metaled surface in excess of 9 feet up to and including 16 feet.

d. Every mile conforming to the above conditions as to grade, width, drainage, etc., and having a bottom course of gravel, slag or other material not less than 4 inches thick after rolling and a top course of crushed stone not less than 3 inches thick after rolling shall merit, if approved, a reward of $750 per mile, with an extra $75 per mile for each additional foot in width of metaled surface in excess of 9 feet up to and including 16 feet.

e. Every mile conforming to the foregoing as to width, grade, drainage, etc., and having a surface of well compacted macadam not less than 6 inches thick at edges, 7 inches at center laid in not less than two courses, each properly bonded, shall merit, if approved, a reward of $1000 per mile, with an extra $100 per mile for each additional foot in width of metaled surface in excess of 9 feet up to and including 16 feet.

f. Every mile conforming to the foregoing as to grade, drainage, etc., and having properly laid concrete not less than 6 inches in thickness with or without a paving brick surface, shall merit, if approved, a reward of $900 per mile, with an extra $100 per mile for each additional foot in width of metaled surface in excess of 8 feet up to and including 16 feet.

g. Every mile conforming to the foregoing as to grade, drainage, etc., and consisting of a paving brick surface laid on gravel, sand, broken stone or slag, the quality of brick, manner of laying and kind of inspection employed to be made to comply with the specifications made by, or approved by the State highway commissioner, shall merit, if approved, a reward of $900 per mile, with an extra $100 per mile for each additional foot in width of metaled surface in excess of 8 feet up to and including 16 feet.

Firm earth, gravel or macadam shoulders must be placed on each side of the concrete and brick 8-foot metal track.

Two or more townships may act jointly in the improvement of boundary line roads.

The State highway department is required to design, construct and maintain all bridges of 30 feet clear span and over on State trunk line roads, provided the county, township or good roads district agrees to construct at least 3 miles of road including the bridge site. The State highway department is required to design, construct and maintain all bridges of more than 30 feet clear span on State reward roads, if the county, township or good roads district spends in building the road or roads including the bridge site an amount, not including the State reward, equal to the estimated cost of the bridge plus the State reward merited.

The 1913 legislature of Michigan passed what is known as the trunk line highway act, which delineates certain highways leading from town to town in the State, totalling about 3000 miles, upon which townships and counties will be entitled to double the State rewards mentioned above, when they build roads according to specifications drawn by the State highway department. The fixing of the location of these routes between towns, the preliminary surveys and the drafting of specifications are in the hands of the State highway department, while the construction of the roads is in the hands of the townships and counties through which they pass. The law provides that the total allowable mileage of trunk lines in any county may equal the number of surveyed townships multiplied by 3. On this basis the total allowable mileage of trunk lines is 4785.

The 1915 legislature authorized the local township officials or, where the county road system had been adopted, the county highway officials and the State highway commissioner, to lay out additional trunk line mileage up to 3 miles per surveyed township.

Local Road Laws

The commissioner of highways of each township has charge of town roads and the board of county road commissioners of each county adopting that system has charge of county roads.

The Assessment District Law provides that a petition signed by 51 per cent of the abutting land owners may be presented to the board of county road commissioners where the county road system is in force or to the State highway commissioner elsewhere for the improvement of not less than 2 miles of road. Not less than 25 per cent nor more than 75 per cent of the cost is borne by the local assessment district and the remainder by the townships benefited or the county where the county road system is in force.

Road Bond Legislation

The township board of any organized township, upon petition of at least twenty-five freeholders thereof, may submit to an election the proposition of issuing bonds of the township in an amount not exceeding 5 per cent of the assessed valuation thereof, for improving the roads therein under the commissioner of highways, subject to direction of the township board a majority of the legal voters voting is necessary to authorize the bond issue. These bonds shall bear not to exceed 5 per cent interest and shall run not to exceed twenty-five years, and a tax shall be levied annually to meet the interest and principal as fast as they become due.

Counties that have adopted the county road system may issue bonds to pay for such improvements as the commissioners of highways decide to make, in an amount not exceeding 3 per cent of the valuation of property assessable for this purpose. Before issuing these bonds, the county board of supervisors must order an election to decide on the issue. A majority of votes cast is required to authorize the bond issue. Bonds shall not be sold for less than par and shall run for not exceeding twenty years. The rate of interest and method of payment are not specified.

Convict Labor Law

County road officials may direct the employment of county prisoners confined for petty offenses, upon the highways of the county.

The wardens of the State penitentiaries may, upon proper application from highway officials, put State prisoners to work in the same manner as county prisoners. State convicts may also be used in surface quarries and stone yards in preparing material to be used on the public highways.

Automobile Registration

All automobiles must be registered annually with the secretary of State. The fees for steam and gasoline vehicles are 25 cents per horse power plus 25 cents per 100 lbs. weight. The fees for electric vehicles are $1 per horse power plus 25 cents per 100 lbs. weight. Half the money is returned to the counties for road purposes and half is paid into the State reward fund.

Highway Officials

Frank F. Rogers, *State highway commissioner*, Lansing; Leroy C. Smith, deputy highway commissioner.

Progress Report

During the fiscal year ending June 30, 1916, 1092.844 miles of road were accepted for State reward, thus bringing the total mileage constructed under the supervision of the State highway department up to 4,289.310 miles. It is estimated that at least 1200 miles will be built during the 1917 fiscal year. Approximately 5000 miles were completed January 1, 1917.

The sum of $604,173.48 was expended during 1916 in the payment of construction and repair rewards on ordinary State rewarded roads. The payment of rewards, making surveys, and construction of bridges on trunk line roads totalled $353,032.51 during the 1916 fiscal year. The departmental expenses were $25,732.95.

Thirty trunk line bridges were built during the 1916 fiscal year, in the construction of which $100,758.75 was expended.

Road Funds

For 1917 the amount credited to the State highway funds is estimated at $1,580,000, distributed as follows:

Automobile tax (estimated)	$1,000,000
Trunk line fund	550,000
Expense fund	30,000

Roughly, about $10,000,000 will be expended by the counties and townships of the State in the construction of roads during 1917. Several counties voted large bond issues for road building at the November election in 1916. Among these were: Genesee county, $1,000,000, Calhoun county, $800,000, Ontonagon county, $195,000, and Baraga county, $125,000.

[Approved by FRANK F. ROGERS, State Highway Commissioner.]

MINNESOTA

State Aid Legislation

The State highway commission consists of three members appointed by the governor and holding office for three years and serving without compensation, one new commissioner to be appointed each year. The commission holds meetings not less than once in each month and appoints a secretary who shall be a civil engineer and practical road builder and be known as the State engineer, and holds office subject to the pleasure of the commission. They may also employ other assistants and fix their compensation. The commission shall make report to the governor annually.

The State engineer is required to give advice under the rules of the commission and to perform such other engineering services for other State departments as the governor may require. He shall make all necessary surveys, establish grades, prepare plans and specifications, and have supervision of all work on State roads. He shall make an annual inspection of all bridges exceeding 30 feet in length, shall make report on their condition with recommendations to the State highway commission and county boards. The commission is authorized to investigate the location of road materials, investigate methods of construction, systems of road administration, hold public meetings, and apportion State aid.

A State road fund is created by an annual tax levy of 1 mill on each dollar of valuation, together with all money accruing from investments in the internal improvement land fund, 5 per cent from the sale of U. S. land, proceeds from milk and cream testing licenses, and the net proceeds from motor vehicle licenses. The State highway commission allots this fund to the various counties, but no county shall receive in one year more than 3 per cent nor less than 1 per cent. Twenty per cent of the allotment shall be used only for maintenance of State roads and bridges. In determining the percentage accruing to each county the commission shall take into consideration the area, the amount of money expended in road construction, the difficulty and expense of such construction, and the extraordinary expense connected with the development of new territory.

Any county board may with the consent of the highway commission designate any established road in the county as a State road, and, if the cost does not exceed $500, cause surveys to be made when necessary by a State assistant engineer and then proceed with the construction. If the cost is over $500 the county board shall cause survey and plans and specifications to be made by the assistant State engineer and submit the same to the State highway commission for approval. When such approval has been obtained the county board proceeds to do the work under the supervision of the assistant State engineer, who acts under instructions of the State engineer. After completion, if the State highway commission approves the work, the State engineer certifies to the same and a warrant is issued by the State auditor for a share as provided by the law of the amount expended, but in no case shall the warrant exceed the amount allotted to such county. The assistant engineers throughout the State are appointed by the State highway commission and act under the instructions of the State engineer. The appropriation for State highway department is $100,000 per annum.

Local Road Legislation

Jurisdiction over local roads lies with the county and township boards. The counties are required to construct and maintain

State roads and must construct county roads. To finance this work the county board is authorized to levy not to exceed 3 mills each year and receive State aid in proportion to the valuation of the county. The county may purchase machinery and do its work by contract or day labor. The counties generally have a superintendent in charge of the work for the county board. County roads are laid out by petition of 24 or more voting freeholders and a road which has been traveled for six or more years also becomes a county road by adverse possession. Towns are required to construct township roads and to maintain county and township roads. Each town constitutes a road district and there is one overseer with necessary assistants to supervise the work under the direction of the town board. The electors may vote a tax on the town not exceeding 15 mills, and subsequently the town board may in case of emergency, levy an additional 5 mills, the proceeds of which constitutes the town road and bridge fund. This fund is used for construction and improvement of town roads, for which contracts are entered into, or the work is done by day labor, as the town board elects. There is also a compulsory tax of 1 mill levied by the county auditor, and paid to the town, which forms the dragging fund, used only for dragging the township and county roads and for purchasing drags.

Road Bond Legislation

On petition of 50 or more voters who are freeholders of the county, the county commissioners may submit to vote the proposition of issuing county bonds for road purposes. If a majority of those voting are in favor of the proposition, the county board shall issue bonds of the county in such amount as will not, with existing indebtedness, make the total indebtedness of the county exceed 15 per cent of the assessed valuation of taxable real property therein. These bonds shall bear not to exceed 6 per cent interest, shall have coupons attached, and shall be paid in equal installments—the first to become due and payable not less than five years after the date thereof, and the last not more than twenty years after such date.

The town board, to make extraordinary improvements that will cost more than the town is otherwise authorized to appropriate, on petition of 15 or more voters of the town owning real estate therein, may submit the question of the improvement to the next annual town meeting, or, if so requested, may call a special town meeting to vote on the question, and a 60 per cent majority vote shall authorize the improvement. The town board may then issue bonds of the town to raise the necessary funds. The amount of these bonds, with the existing indebtedness of the town, shall not exceed 5 per cent of the assessed valuation thereof. Such bonds shall bear not to exceed 6 per cent interest, shall have coupons attached, and shall be due in ten equal installments, the first of which shall become due and payable not more than eighteen months after date, and one each consecutive year thereafter. A tax shall be levied to pay the interest and principal of such bonds as they become due.

Convict Labor Law

No legislation providing for convict labor upon highways. They may be used for crushing stone for highway purposes on the prison grounds.

Automobile Registration

The law provided for triennial registration with the secretary of State. Registration fees are as follows: All motor vehicles, $1.50; dealers and manufacturers, one machine in each class, $10; chauffeur's license, $3.

After January 1, 1918, the fee will be $5 for the triennial period beginning then; after January 1, 1919, the fee will be $3.50 for the two following years, and after January 1, 1920, the fee for that year will be $2.00; after January 1, 1918, dealers' registration, $20, and $1 for each extra set of tags.

The net registration revenue is paid to the State treasury to the credit of the general fund. It amounted to $80,000 in 1916.

Highway Officials

State Highway Commission, St. Paul.—C. M. Babcock, chairman; Fred B. Lynch, Clarence I. McNair. George W. Cooley, State engineer and secretary of commission; John H. Mullen, chief road deputy; Carl E. Nagel, chief bridge deputy; S. C. Notestein, chief clerk.

Progress Report

In 1916, the work done comprised about 1,400 miles of grading, 1,100 miles of grading and graveling, 12,000 miles of State maintenance and 400 bridges. This work cost about $4,500,000 and does not include any of the town and miscellaneous county work.

[Approved by GEORGE W. COOLEY, State Engineer.]

MISSISSIPPI

State Aid Legislation

In 1916, a State highway commission was created but no provision has been made for the use of State funds for road construction. The law creating the department provides that if the legislature approves a bond issue for carrying out the commission's recommendations, the issue must be authorized by a majority vote of the electors. The commission and the State highway engineer appointed by it constitute the State highway department.

The State highway engineer is required to plan the improvement of such main roads, with their bridges, as will form a connected system of highways throughout the State, and the improvement of other roads designated by the commission; to ascertain the methods of construction and maintenance best adapted for all local conditions within the State; to give advice regarding bridges and buildings to local officials. The law requires county and road district highway officials to secure his approval of their plans, specifications and estimates before submitting them to the higher local officials for adoption. County and district officials are required to furnish to him upon request information regarding their roads and bridges, and are liable to a fine of $10 to $100 if they fail to do so. The department must hold at least one meeting annually in each county if requested to do so, to discuss highway matters with the county and district road officials. The apparatus and supplies of the University of Mississippi and the Agricultural and Mechanical College may be used by the department for testing road and bridge materials.

Local Road Laws

The State constitution prohibits the passage of local laws by the legislature exempting any person from road duty or relating to laying out, opening, altering, working and vacating roads. All such matters must be provided for by general laws.

Jurisdiction over all roads in a county lies in its board of supervisors. Each county is divided into five supervisors' districts, each of which may carry on its road work under the direction of three commissioners appointed by the board of supervisors. The county board may also place a county road commissioner in charge of the county roads or any part of them. Road districts containing at least 10 square miles may be formed to build roads under the direction of three road commissioners appointed for 4 years. An entire county may be organized as a road district.

The district commissioners are authorized to do work by contract or day labor. District road systems may include streets in municipalities. A county board may require adjoining road districts to connect their road systems.

Road Bond Legislation

For the purpose of road and bridge improvement, the county board of supervisors may issue bonds of the county to an amount not exceeding, including all of its bonded indebtedness, 5 per cent of the assessed valuation of all taxable property in the county. These bonds shall run not exceeding forty years, shall bear interest at the rate of 6 per cent, and shall be redeemed by a sinking fund to be provided for that purpose by annual taxation.

The board of supervisors of any county is authorized to issue bonds in an amount not to exceed in the aggregate, with outstanding bonded indebtedness, 10 per cent of the assessed valuation of the county, to construct and extend the public highways of the county to connect with the improved highways of adjoining counties, so as to form a continuous system of improved intercounty highways. Such bonds shall bear not to exceed 6 per cent interest and mature not later than 40 years from date of issue.

Supervisor districts may issue bonds for road purposes on petition to the county board of supervisors signed by 20 per cent of the qualified electors of the district. A favorable vote by a majority of those voting at an election to be called for that purpose is necessary to authorize the issue. These bonds shall run not exceeding twenty-five years, shall bear not exceeding 6 per cent interest, shall be exempt from taxation, and shall be sold for not less than par. A tax shall be levied annually to pay the interest and create a sinking fund for the discharge of such bonds at maturity.

Board of supervisors may require adjoining road districts which have constructed, or are constructing, improved roads to connect such improved roads, and apportion the cost thereof to the various districts. Said boards may, if necessary, authorize such districts to issue additional bonds to the amount required to make such connections. If 25 per cent of the electors of any such district, or districts, shall petition against such bond issue, then bonds shall not be issued unless at an election held for that purpose the majority of electors of such district, or districts, respectively, shall vote in favor of same.

When the sinking fund of any road district shall accumulate to an appreciable amount before the time for redemption of the bonds for which it is created, the road commissioners of such district may loan such accumulation at not less than 6 per cent interest on first-mortgage real estate security, on the basis of one-half of its assessed valuation.

Convict Labor Law

There is no general convict labor law in reference to highways. Most convicts are employed upon state farms. The superintendent of the penitentiary is authorized to improve and maintain roads from each convict farm in the State for a distance of 5 miles out from said farms.

In four counties, convicts between the ages of eighteen and and fifty sentenced to the farms may be required to work fifteen days on the roads.

Automobile Registration

Annual registration of motor vehicles is required with the payment of the following fees: Electric motor vehicles $4.80, each commercial vehicle of 4400 pounds capacity or less $8.40, each commercial vehicle of more than 4400 pounds capacity $16.80, motor cycles $2.40, any other motor vehicle 36 cents per horse power. Fees are collected by the regular tax collector, the county board of supervisors being required to furnish him with supply of licenses. Three per cent of the proceeds are paid to the collector for making collections and the balance goes into the road and bridge privilege tax fund of the county in which collected. Non-residents are exempt for 60 days.

Highway Officials

The State highway commission consists of J. M. McBeath, chairman, Meridian; W. T. Denman, secretary, McComb City; and D. W. Robbins, Tupelo. The State highway engineer is Xavier A. Kramer, Magnolia.

Road Funds

The Mississippi apportionment of the federal aid road funds for the first two years amounts to $265,718. In order for this to be available an equal sum must be provided by the State or its subdivisions for expenditure under the general supervision of the U. S. Office of Public Roads. It is estimated that during 1917 about $5,000,000 will be available for all classes of roads from bond issues and about $750,000 from road taxes.

[Approved by XAVIER A. KRAMER, State Highway Engineer.]

MISSOURI

State Aid Legislation

The State highway commissioner is appointed by the governor for a term of four years. The highway commissioner appoints a deputy who must be an engineer. The duties of the commissioner are to prepare plans and estimates for road and bridge construction and hold public meetings, to give assistance and advice to local road officials, to issue bulletins, etc. He has authority over road work and over the distribution of State aid apportioned to the counties, but his work is also investigative, advisory and educational.

Local Road Laws

Road administration in the counties is in the hands of the county court, which consists of three county judges, under what is known as "county organization." The presiding judge is elected for a term of four years. The last election was held November, 1914. The two associate judges are elected for two years in November of even years. The county court appoints, if it desires, a county highway engineer, in January of the even years, who has general supervision over all the roads and bridge work in the county. His term of office is for two years and his office can be vacated by the people by a vote, at any general election, the taxpayers petitioning the court to hold an election for that purpose. The surveyor of the county, which is a constitutional office, is elected by the people and is ex-officio county highway engineer when the court appoints no regulaar county highway engineer.

There are 114 counties in the State and 22 of the counties have voted on themselves a "township organization" under which the township officers handle the road work in their county and appoint their own overseers. At the head of the township organization is the township board, consisting of a trustee and two other members. They have also their own assessor and collector, justice of the peace and constable. Each road overseer in a township organization has a district in the township. In the counties not operating under township organization, the county is divided into road districts of not less than nine miles or more than one municipal township in area and the county court appoints a road overseer for each district. These overseers are responsible to the county highway engineer.

Road Bond Laws

When petitioned by 100 tax-paying citizens of any county, the county court thereof may submit to a vote the question of issuing bonds for road and bridge purposes, and a two-thirds majority vote of those voting is required to authorize the bond issue. Such bonds shall be coupon bonds and issued in such amount as will not, with the existing indebtedness of the county, exceed the constitutional limitation of 5 per cent of the assessed valuation of the taxable property therein; they shall bear not to exceed 5 per cent interest, shall be exempt from taxation, and shall mature and be payable within 20 years upon the call of the county court. The principal, sinking fund and interest of these bonds shall be paid by a tax levied for this purpose.

Special road districts may be organized and the board of commissioners thereof may call an election to determine whether bonds shall be issued for road purposes. A two-thirds majority of those voting shall be necessary to authorize the issuance of these bonds, which, if issued, shall be in an amount, including existing district indebtedness, not to exceed 5 per cent of the assessed valuation of the district. The bonds shall bear not exceeding 6 per cent interest, shall become due in not exceeding fifteen annual installments, the first of which shall become due not later than two years after the date of the bonds. The bonds shall be sold to the best advantage by the board of commissioners.

Convict Labor Laws

The warden and inspectors of the penitentiary may, in their discretion enter into contracts for the employment of not to exceed 300 convicts of the state penitentiary upon public roads and highways of the State at such times and places and upon such terms as the warden and inspectors deem proper.

Automobile Registration

The law provides for annual registration with the secretary of State. The schedule of fees is as follows: Less than 12 h.p., $2; 12 to 23 h.p., $3; 24 to 35 h.p., $5; 36 to 47 h.p., $7; 48 to 59 h.p., $8; 60 to 71 h.p., $10; 72 h.p. and over, $12; dealers and manufacturers, $16; chauffeur's license, $1.50. It is expected that the legislature in session at the time of going to press will change these fees.

The registration revenue is paid into the State treasury to the credit of the State good roads fund, but specific appropriation by the legislature is necessary before expenditures are made.

Highway Officials

Highway Department.—Frank W. Buffum, State highway commissioner; E. W. Sheets, deputy commissioner; H. B. Bode, inspector. Offices, Jefferson City, Mo.

Road Funds

All the money received from automobile licenses, less collecting expenses, is deposited with the State treasurer to the credit of the general road fund. All the money received from corporation charters and from the annual dues and corporation taxes less the collecting expense also goes into said fund. From this fund, the legislature every two years appropriates the sum in its opinion necessary for dragging the highways which go from each county seat to the county seats of the adjoining counties, amounting to approximately 14,000 miles. This money is paid at the rate of $15 a mile for routes approved by the State highway department. The money must be used for dragging except where the conditions are such that it can not be so used, and for road betterments such as culverts and bridges, but not for buying right-of-way. Three highway commissioners, appointed by the county court, have charge of the handling of this road drag fund in each county.

After the dragging fund appropriated by the legislature is taken from the general road fund the amount left in the latter fund can be used for permanent improvements. This is apportioned to the different counties according to their assessed valuation, not to exceed 3 per cent to any county, the object being to keep the larger counties from drawing out the entire fund. The amount so apportioned in 1916 was $250,000.

Progress Report

The State highway department has been handicapped by inadequate appropriations for carrying on its work. During 1915 and 1916, 13,362 miles of county-seat and branch roads were approved by the department. Most of these roads have been drained, graded, and dragged by the State fund of $15 a mile. There has been some graveling and macadamizing on these highways. In most cases the counties receiving State aid have endeavored to comply with the specifications and instructions furnished by the department. Many sections of the State are just awakening to the benefits of road improvements, and as they have many miles of poor roads, the department is urging them to buy large tractors and heavy road machinery, so as to carry on the work at a low unit cost, and to build substantial culverts and bridges. The department is also urging the purchase of tractors or motor trucks and trailers where the amount of graveling or macadamizing warrants this. The standard right-of-way has been fixed at 40 feet, with extra width at right-angle turns.

[Approved by E. W. Sheets, Deputy State Highway Commissioner.]

MONTANA

State Aid Legislation

Under an act of the legislature passed in 1913, the governor is required to appoint a State highway commission of three members consisting of the professor of civil engineering of the Montana State College of Agriculture and Mechanic Arts, ex-officio; the State engineer, ex officio; a civil engineer who is a trained and experienced road builder, who is required to devote his entire time to the work. The commission is required to meet not less than once a month. The duty of the commission is to give advice, assistance and supervision in regard to road construction and maintenance, throughout the State.

The board of county commissioners in each county was required within six months after the passage of the act to prepare duplicate road maps of all public roads in the county as well as public roads constituting boundaries between counties and designate on the map such roads as the county board considered of sufficient importance to justify their improvement under this act. One of the maps was filed with the county clerk and the other forwarded to the State highway commission with a statement of the location in the county of all deposits of road material. If the county board failed to carry out the provisions of the act, the State highway commission might proceed to obtain the information and deduct the amount thus expended from the first apportionment to such county.

The State highway commission was required to prepare a map showing all public roads in each county, and all roads which the commission deemed of sufficient importance to entitle them to State aid. The commission might in coöperation with the county commissioner divide the roads into two classes, one of primary importance and the other of secondary importance, the primary roads to be the first improved.

A State highway fund was created consisting of $5000 direct appropriation to pay the expenses of the commission until the amount credited to the State highway fund was available, thereafter the expenses of the highway commission to be paid out of the said highway fund. Each county is required to levy an annual road tax of not less than 2 mills or more than 5 mills and a road poll tax of $2; the money thus raised forms the general road fund of the county. Each county may also levy a special tax not exceeding 2½ mills for constructing and maintaining bridges. Two-thirds of all receipts of a county from forest reserve funds must be credited to its general road fund.

The act states that on or before the first Tuesday of March of each year the highway commission shall apportion the State highway fund among the different counties of the State and notify their respective boards of county commissioners. The highway commission is given discretion as to the amounts to be apportioned to the representative counties and is required to take into consideration the area of the county, the amount of money to be expended by it, the difficulty and expense of road construction and extraordinary expenses connected with the development of new territory. The commission is not allowed to spend any of the funds within the corporate limits of cities or towns or in any of the counties in which the county commissioners have not provided for the raising of an amount equal to the amount set aside by the State highway commission. If any county within ninety days fails to avail itself of the act, the highway commission may apportion its allotment among the other counties. The commission is authorized to adopt rules and regulations for the construction and maintenance of State roads. The board of county commissioners is required to make the necessary surveys, plans, specifications and estimates for State roads, in accordance with rules and regulations of the State highway commission, which is authorized to approve or disapprove of the same. The actual construction or maintenance of State roads is under the direction of the State highway commission. The boards of county commissioners may for such work employ a competent civil engineer at not to exceed $12 per day. Contracts are let by the boards of county commissioners.

The boards of county commissioners are required to make a report on or before December 30 of each year to the State highway commission showing in detail all money expended by such county during the current year in the construction and maintenance of the public roads. One part of the report shall cover State roads and the other portion cover all other roads.

The State highway commission is required to make a biennial report to the governor.

Local Road Legislation

Jurisdiction over roads vests in elected boards of county commissioners, who appoint a county surveyor and divide the counties into districts with one or more overseers in each. Special bridge and road districts may be created by election but the taxes are levied and collected by the county boards.

Road Bond Legislation

The board of county commissioners of any county may issue coupon bonds in an amount which, with the outstanding bonded indebtedness, will not exceed 5 per cent of the assessed valuation of the taxable property therein; provided that no county shall incur any indebtedness or liability for any single purpose to an amount exceeding $10,000, without the approval of a majority of the electors thereof.

Convict Labor Law

County commissioners may require prisoners to labor "on the public works or ways in the county."

Under the State highway commission, act of 1913, county commissioners may have work done by prison or convict labor on State roads in their county.

Automobile Registration

The law provides for registration with the secretary of State. Schedule of fees is as follows: All motor vehicles, $2; chauffeur's license, perpetual, $2.

The net registration revenue is paid into the State treasury and credited to the State highway fund, to be expended in constructing State roads and for apportionment to the several counties of the State.

Highway Officials

State Highway Commission, A. W. Mahon, Helena, State engineer, chairman; Geo. R. Metlen, secretary; Prof. L. D. Conklin, Bozeman.

[Approved by Geo. R. Metlen, Secretary State Highway Commission.]

NEBRASKA

State Aid Legislation

The county boards of commissioners are required to have bidders on bridge work use forms provided by the secretary of State board of irrigation. The county boards are forbidden to let a contract for a bridge costing over $500 except upon plans and specifications of the secretary of the State board of irrigation, who is required also to inspect and check that completed work.

The State board of irrigation is constituted by law. The State board of supervision for bridges and the State engineer are empowered to carry out the orders of the board.

The board of county commissioners may make application to the State board of irrigation for State aid in the construction of any bridge over a stream of 175 feet or more in width, pledging the county to furnish one-half the cost of construction, and, if the application is approved by the State board, the contract is let jointly by the said county board and the State board of irrigation. The plans and specifications are furnished by the State engineer and the construction is under the joint supervision of the State board of irrigation and the board of county commissioners. A State levy of one-fifth of 1 mill on the dollar constitutes the "State aid bridge fund."

The State board of irrigation, highways and drainage is empowered to advise with county boards on highways and bridges. The board appoints an advisory board of three members authorized by law to supervise the expenditure of any funds that may be provided by the federal government for highway and bridge construction.

At the time of going to press legislation was proposed authorizing the State engineer to lay out a system of inter-county roads and a tax to meet federal aid funds in constructing them.

Local Road Legislation

In some counties, the board of county commissioners divides the county into districts, in each of which an overseer is elected annually; the board appoints a county highway commissioner annually. In the other counties, each county is divided into seven districts, in each of which the electors choose a road supervisor.

Road Bond Legislation

Any county, township, precinct, city, or village may issue bonds to construct a highway bridge across any boundary river of the State, if so voted by three-fifths of the voters at a special election. The amount of bonds must not exceed 10 per cent of the valuation. In any county, township, precinct, city or village which has made donations to railroads or other internal improvements, a two-thirds vote shall be required for such bonds. The interest shall not exceed 7 per cent. There shall be an annual tax for interest and sinking fund. The term of the bond is not designated.

Similar provision is made for purchasing private bridges within any township or across any river bounding a township. For such purpose a two-thirds majority is required and the bonds shall bear not to exceed 8 per cent interest. A yearly tax must be levied to pay 5 per cent of the principal annually and the interest on the bonds. Any county or city in the State is authorized to issue bonds for internal improvements, and it appears that such improvements include highways.

Convict Labor Law

For the purpose of enabling the county commissioners to employ in a profitable manner all convicts sentenced to hard labor, the board has authority to make rules and regulations and designate the place where the convicts shall work. The county jail is declared to extend to any quarry, road or other place the commissioners may designate.

Automobile Registration

Annual registration fee, $2 for motor cycle, $3 for automobile, $5 for commercial truck, $5 for dealer. About four-fifths of the proceeds is paid into the road-dragging funds of the counties where the fees are obtained.

Highway Officials

State Engineer.—Geo. E. Johnson, Lincoln; W. D. J. Steckelberg, assistant State engineer, Lincoln.

Road Funds

There is a State tax of 0.2 mill for aid toward bridge construction and maintenance, which furnished about $75,000 in 1916. If the legislature of 1917 passes the highway laws contemplated about $1,000,000 will be spent during the year on roads and a considerable sum on bridges.

[Approved by GEORGE E. JOHNSON, State Engineer.]

NEVADA

State Aid Legislation

A law passed by the legislature of Nevada, and approved by the governor March 16, 1911, provided that the State engineer should have general supervision of road work carried on by convict labor. An appropriation of $20,000 was made to cover the work, which was of the nature of an experiment. No later appropriations have been made.

New highway legislation was under discussion in the legislature when this book went to press.

Local Road Legislation

The local roads are under the jurisdiction of the boards of county commissioners, which divide the counties into districts with one or more overseers in each.

Road Bond Legislation

On a majority vote of the qualified electors of any county, the board of county commissioners may issue bonds of the county to create a fund to be known as the "county road and bridge fund," to be used in the construction, repair, and maintenance of the county roads and bridges, and the purchase of necessary implements and machinery for this purpose. The amount of these bonds shall not exceed the equivalent of 3 per cent of the total assessed valuation of the real and personal property in the county. The bonds shall have interest coupons attached, shall bear not to exceed 6 per cent interest, shall be in denominations of $1000, $500 or $100, as determined by the board of county commissioners, and shall be numbered consecutively from first to last, and must not be sold for less than par. On January 1 of the third year succeeding their sale and annually thereafter, one or more of these bonds, as shall be designated by the board, in consecutive order, shall be paid and redeemed by the county, and an annual tax shall be levied to pay the interest on them and to create a sinking fund for their retirement.

Convict Labor Law

The State prison commissioners are authorized to detail for work on the public highways any male convict in the State prison who may be properly detailed, except prisoners under sentence of death, provided, that such detail shall be voluntary on the part of the convict.

Convicts so detailed are not required to wear stripes, are given ten days off sentence for each month's faithful work, and are paid 10 cents per day.

Automobile Registration

The law provides for annual registration with the secretary of State. The registration fee is 12½ cents per h.p., minimum fee, $2.50. Motorcycles exempt.

The net registration revenue, when it aggregates $25,000, shall be apportioned to the several counties of the State for construction of county roads under the joint supervision of the county commissioners and the State engineer. (Chapter No. 206, Laws 1913.)

Highway Officials

The State engineer no longer has any connection with road work, which is under the county surveyors and road overseers.

[Approved by W. M. KEARNEY, State Engineer.]

NEW HAMPSHIRE

State Aid Legislation

In 1915, the legislature abolished the office of State engineer and created a State highway department, in charge of a highway commissioner appointed for five years by the governor. He has charge of the location, construction and maintenance of roads built in part or wholly with State funds. All technical features of the work, the award of contracts and the supervision of construction are under his control, but the taking of land or materials by eminent domain is under the governor and council. Appeals from his decisions may be taken to the governor.

Prior to 1915, three north and south trunk lines and three cross lines were authorized. In 1915, eleven more cross lines were authorized. All State-aid funds spent in the cities and towns through which these roads pass must be expended on these roads until they are finished. The State contributes toward such work one-half the cost and such further sums, in towns unable to pay half the cost, as the highway commissioner considers equitable. The work is done by contract or by local authorities under the direction of the State highway department. If a city or town neglects or refuses to raise its proportionate part of the cost of construction of trunk line road within the town, the State may do the work and assess the town for its proportionate part, charging the same to the State tax of that town. This charge is not to exceed 0.25 to 1 per cent of the town valuation in any one year.

Aside from the State highways the State grants aid to the towns on the following plan:

Each town, out of the money raised for highway purposes, shall set aside the following amount for the improvement of its highways under the supervision of the State engineer: Towns having a valuation of less than $2,000,000, $1 on each $1000 valuation; towns of $2,000,000 and less than $3,000,000 valuation, 75 cents on each $1000 valuation; towns of $3,000,000 and less than $5,000,000 valuation, 50 cents on each $1000 valuation; towns of $5,000,000 and less than $15,000,000 valuation, 33⅓ cents on each $1000 valuation; towns from $15,000,000 and upward valuation, 25 cents on each $1000 valuation; counties in which are located unincorporated towns, $1 on each $1000 valuation. If a town desires State aid for permanent improvement in addition to the improvement provided by the foregoing method, it shall raise an additional amount equal to 50 per cent of this sum and then make application for State aid. They shall then receive for each additional dollar so set apart the following amounts: Towns having a valuation of less than $100,000, $3 for each $1 so set apart; $100,000 and less than $150,000, $1.25 for each $1; $250,000 and less than $500,000, 60 cents for each $1; $500,000 and less than $1,000,000, 40 cents for each $1; $1,000,000 and less than $3,000,000, 25 cents for each $1; $3,000,000 and upward, 20 cents for each $1.

The amounts thus set aside by the towns, respectively, constitute a joint fund for permanent improvement.

The State road funds for trunk lines are provided by State bonds bearing not to exceed 3½ per cent interest. A direct appropriation is made annually for paying interest and installments on the bonds. The regular State aid not on trunk lines is met by current appropriations.

Local Road Legislation

County commissioners have jurisdiction over roads in unincorporated places and selectmen over town roads. A part of the property road tax is rebated to persons complying with the wide-tire laws.

Automobile Registration

The law provides for annual registration with the commissioner of motor vehicles. The schedule of fees is as follows: Motor cycles, $2. Automobiles, 15 h.p., and less, $10; 16 to 30 h.p., $15; 31 to 40 h.p., $20; 41 to 50 h.p., $25; 51 to 60 h.p., $30; 61 h.p. and over, $40. Motor trucks and automobiles used for carrying passengers for hire, on same basis.

The net registration revenue shall be expended in the maintenance of highways in accordance with the State highway laws, provided that 35 per cent of such net revenue may be expended in the maintenance of roads in cities, towns and places where roads are not ordinarily maintained with assistance of the State. Fines and forfeitures are paid into the State treasury for use in the same manner as registration revenues.

Highway Officials

State Highway Department, Concord.—F. E. Everett, State highway commissioner; C. C. Howe, chief clerk.

Division Engineers.—F. W. Brown, Concord; W. A. Grover, Dover; H. L. Smith, Lakeport; C. M. Brooks, Keene; O. M. James, Northwood Narrows; C. H. Chandler, Whitefield; C. P. Riford, Concord; F. H. Colburn, Concord.

Progress Report

During 1916, 107.09 miles of road were improved, comprising 11.58 miles of grading, 87.60 miles of gravel roads, 7.91 miles of macadam, and 7.91 miles of road have been rebuilt with bituminous macadam.

There are 15,116 miles of roads in the State, of which 1255.18 miles have hard surfacing.

Road Funds

For construction in 1916 there was available approximately $275,000 State money and $300,000 town money. The exact figures are not available at this date to show expenditures.

For maintenance purposes in 1916, the State spent $299,696.02 in connection with which the towns spent $137,958.69, a total of $437,654.71. The average cost per mile for trunk line maintenance was $434.51 and for State aid maintenance $191.19.

About the same amount of money will be available in 1917.

Progress Report

Of the three trunk lines originally authorized there is left to build 35.57 miles. The legislature of 1914–15 authorized the State highway commissioner to lay out a system of cross State highways. This work was completed in 1916, the different lines being given a distinguishing color and the poles banded. These so-called cross State highways are approximately one-third completed, this construction having been done under State aid in the past. The legislature of 1916–17 will be asked to make appropriations to complete the 35.57 miles on old trunk lines and an appropriation to commence work on the cross State highways.

[Approved by F. E. Everett, State Highway Commissioner.]

NEW JERSEY

State Aid Legislation

The State highway commission consists of the governor, president of the senate, speaker of the house of assembly, the State treasurer, who serve without compensation, and the commissioner of public roads.

The commission is required to establish a continuous State highway system of improved main traveled roads connecting counties, cities, seaside resorts, large centers of population, outlets at the boundaries of the State, the Ocean Highway, and the Delaware River Drive, and the State commissioner of public roads is directed to submit to the commission a map showing the proposed system, the aggregate mileage of which shall not exceed 1500 miles.

The commissioner of public roads is appointed by the governor for three years. His staff is composed of civil-service employees who hold office, unless removed for cause; a State highway engineer who is chief engineer; and four-division engineers, ten regular inspectors and foremen who are intended to form the nucleus for a trained corps of inspectors. In addition to this force the commissioner may appoint a local supervisor or inspector when necessary on each contract at a per diem compensation. All of the staff are under civil service rules and regulations.

The State commissioner of public roads is directed to take charge of the construction, improvement, and maintenance of the State highways comprising the State highway system, all such work to be done at the expense of the State, or upon the basis of an equitable agreement between the county authorities and the commission, the plans and specifications to be prepared by the State highway department and supervision to be exercised by the department.

The commissioner of public roads is intrusted with the execution of the law granting State aid in the improvement of highways, such highways being in addition to the State highways. The commissioner, after conference with the board of chosen freeholders in respective counties and other local authorities, passes upon requests for aid in road improvement. The surveys, plans, estimates, and specifications are made locally, but must be approved by the State commissioner of public roads before the local authorities advertise for bids. Later the contracts and bonds are examined and approved by the commissioner before work begins. After the work has been completed to the satisfaction of the local authorities a written statement with detailed cost data is submitted to the commissioner, and if after inspection it is approved by him the State's portion of the cost, amounting to 40 per cent, is sent to the county.

After final approval by the State commissioner of public roads such roads shall thereafter be county or municipal roads, to be maintained by the county board of freeholders and the county supervisor or by the township or municipal officers. If the county fails to repair the road within 60 days after notice in writing by the State commissioner, he shall certify such neglect to the State comptroller, who shall withhold payment to the county of any money that may be apportioned to it until such repairs are made. The State road fund includes appropriations made by the legislature and the receipts from motor vehicle licenses and fines.

The commissioner of public roads may grant aid in the construction of bridges on roads being improved to the extent of 20 per cent of their cost, otherwise the State takes no part in the cost of building or maintaining bridges, the only exception being the bridge over the Raritan River to Perth Amboy, for the maintenance of which the State pays one-third in accordance with the terms of a statute passed in 1912.

Local Road Legislation

The county roads are under the board of chosen freeholders of the county, which appoints a county road supervisor and a county engineer in charge of the bridges and roads.

Road Bond Legislation

The board of chosen freeholders may issue bonds of the county in an amount, including existing indebtedness, not to exceed 8 per cent of the assessed value of the real estate therein; provided that in no case shall the amount of such bonds outstanding at any one time exceed $300,000. Such bonds shall bear not to exceed 6 per cent interest and shall run from 5 to 20 years. Before issuing such bonds, the board of chosen freeholders shall make written application to the circuit court for authority to issue the bonds, which court shall investigate and determine whether or not the issue shall be made.

The board of chosen freeholders of a county, the township committee of a township, or the proper governing body of other municipality, may, by resolution, issue bonds thereof to pay the share of such county, township, or other municipality in the cost of State-aid road work therein. Such bonds shall bear not to exceed 5 per cent interest and shall run for not exceeding 30 years.

The board of chosen freeholders of any county is authorized to repair or reconstruct county roads and to issue bonds in payment of the cost thereof. Such bonds shall bear not to exceed 5 per cent interest and shall be payable at any time not exceeding 5 years from date of issue.

When a navigable stream marks the dividing line between two or more counties and the boards of chosen freeholders of such counties, respectively, shall have resolved, or may resolve, that a bridge across such stream is a public necessity, or that an existing bridge across said stream should be rebuilt, the same may be done by the said boards of chosen freeholders jointly, the expense thereof to be borne by such counties in such proportions as may be agreed upon by the said boards of chosen freeholders. If desirable, bonds may be issued by each county for its proportionate share of the cost of such bridge. Such bonds shall bear not to exceed 4½ per cent interest and run for not exceeding 30 years.

To meet the expenses incurred for the acquisition, development and improvement of parks and parkways in any county, the board of chosen freeholders may, from time to time, in addition to any bonds theretofore authorized by law, on the requisition of the board of park commissioners, borrow money by issuing the bonds of said county, not exceeding in the aggregate $650,000, to run for not exceeding 50 years and to bear not to exceed 4½ per cent interest.

It is provided (Chapter 245, L. 1914) that a commission may be appointed for three or more contiguous counties to construct one or more bridges or tunnels over or under a navigable stream or river which forms a part of the boundary of the State, and such counties may, respectively, issue bonds to meet the cost thereof. Such bonds shall be issued in such amounts and shall bear such interest, not exceeding 5 per cent, and be payable at such time as the governing bodies of such counties may, by resolution, determine.

Convict Labor Laws

The board of chosen freeholders of any county may order the sheriff to cause all able bodied male convicts or so many as may be required, to be put to work on the public roads of the county.

The management of the State prison shall be vested in a board of inspectors, consisting of six members, to be appointed by the governor with the advice and consent of the senate. The said board of inspectors is authorized to enter into an agreement with the State commissioner of public roads, or other department of the State government, for the employment of prisoners on public work.

The State commissioner of public roads, or the board of chosen freeholders of any county may make application to the prison labor commission for convicts to work on public highways. The prison labor commission in conjunction with the governing body of the penal institution determine the number to be assigned the cost of maintenance and compensation and may enter into an agreement for the payment of costs or any portion thereof.

The prison labor commission is authorized to acquire so much land for agricultural and quarry purposes as may be selected by said commission, and transfer prisoners for agricultural purposes, and to be employed in the quarrying and preparation of building and road materials.

Automobile Registration

The law provides for annual registration with the assistant secretary of State, who is ex-officio commissioner of motor vehicles. The schedule of fees is as follows: 10 h.p. and less, $4.50; 11 to 29 h.p., $7.50; 30 h.p. and above, $15; motor cycles, $2; motor trucks weighing over 4000 pounds, in addition to regular fees, $10; dealers and manufacturers for each car demonstrated, $5; operators, including owners, for cars not exceeding 30 h.p., $2; operators, including owners, for cars exceeding 30 h.p., $4; motor vehicle line carrying passengers operating from and adjoining State, $100.

The net revenue derived from registrations, fines and penalties shall be deposited in the State treasury for use in repairing the more important improved roads of the State, under the direction of the commissioner of public roads. (Chapter No. 113, **Laws 1906 as amended to January 1, 1915.)**

Highway Officials

State Department of Public Roads, Trenton.—Edwin A. Stevens, State road commissioner; Robert A. Meeker, State highway engineer; Division Engineers in Charge of Roads, E. M. Vail, E. E. Reed, Roy Mullins.

Progress Report

During the fiscal year ended October 31, 1916, there were accepted 65.3 miles of new road which cost, including bridges, $1,105,205.70; the State's share of this sum was $347,617.17. There were carried into the present year 37 road and 7 bridge contracts, embracing 101.863 miles of road and costing about $1,676,931.07, of which sum the State's share is $601,155.83. There was spent on convict road labor $69,866.82, and there was carried over on unpaid requisitions $20,060.80.

The total expenditure of the State for repairs was $716,361.69 and there was carried over into the current year repair work on which the State's share will be $1,040,547.69. The 21 counties of the State have spent, exclusive of State aid, $1,719,499.03 for repair work.

The total expenditure of the State for all road purposes, including administration, was $1,226,927.64.

Road Funds

The State appropriations for the year ending October 31, 1917, are: State road fund, $500,000; convict labor, $75,000; department expenses, $26,500; salaries $17,000; township road work, $4,800. The estimated receipts of the motor vehicle fund for the same period are $1,450,000.

[Approved by Col. E. A. STEVENS, Commissioner of Public Roads.]

NEW MEXICO

State Aid Legislation

The State highway commission consists of the governor, the commissioner of public lands and the State engineer, all of whom serve without compensation. The commission is required to meet four times a year, in January, March, June and September, and hold such special meetings as they consider necessary. The commission has general supervision of all highways and bridges constructed or maintained wholly or partly by the aid of State money. The commission is required to construct, prepare and maintain at the expense of the State either wholly or in part such public roads as best serve the interest of the general public, looking to the construction and maintenance of a complete system of highways. The commission is directed to investigate the needs of the various localities and to coöperate with the various boards of county commissioners in road construction.

In order to provide State aid fund an annual tax is levied not to exceed 1 mill on each dollar of taxable property, the sum thus realized to be turned over to the State treasurer and constitute the road fund which is subject to the orders of the highway commission. State highway bonds are also issued.

The commission is required to make an annual report on or before January 1.

The State engineer is the engineer of the highway commission, and subject to its orders, has supervision of the construction and maintenance of all highways and bridges under the State aid act and also has supervision of all county bridges built by contract where the amount exceeds $1000.

The commission is authorized to do educational and investigative work.

In extending State aid preference is to be given by the commission to those counties which shall contribute an amount at least equal to that appropriated by the commission.

Certain specific State roads are provided for by State legislation.

Local Road Legislation

In 1912 an act was passed in New Mexico creating a county road board in each county to serve without compensation and to consist of three members, to be appointed by the State highway commission for a period of three years and to be subject to removal by the commission for cause. The county road boards are required by law to make an annual report to the State highway commission.

Local Bond Legislation

When petitioned by not less than 10 per cent of the qualified electors of the county who are taxpayers, the board of county commissioners may submit the question of issuing bonds of the county for road purposes. A majority of those voting is required. The amount of the bonds shall not exceed in the aggregate, including existing indebtedness, 4 per cent on the value of the taxable property within the county, shall bear not to exceed 5 per cent interest, and shall run not to exceed thirty years, but may be made redeemable prior to the date of their maturity, as may be provided by order of the board of county commissioners. An additional annual tax levy shall be made to meet the interest charges on the bonds, and there shall be created a fund to be known as the "county highway sinking fund," which shall be used for the redemption of bonds so issued.

Convict Labor Law

Aside from the special acts of the legislature which provides for building certain roads by convict labor, a general act of 1909 provides that the State highway commission shall employ such convict labor as shall be available and advisable. The board of penitentiary commissioners shall on demand of highway commission furnish available convicts and also necessary guards, provided that the cost of transportation, maintenance and guarding while engaged in road work shall be paid from the road fund.

Automobile Registration

The law provides for the annual registration with the secretary of State. The schedule of fees is as follows: Less than 12 h.p., $2; 12 to 19 h.p., $4; 20 to 29 h.p., $6; 30 to 39 h.p., $8; 40 to 49 h.p., $10; 50 h.p. and over, $12; dealers and manufacturers, $12.

The net registration revenue shall be paid into the State treasury and half credited to the State highway fund for expenditure upon the public highways of the State, preference being given to automobile routes and the other half paid to the counties from which it is derived.

Highway Officials

State Highway Commission, Santa Fe.—E. C. DeBaca,[1] governor; Robert P. Ervien, land commissioner; James A. French, State engineer.

Progress Report

During 1916, the State highway commission graded and surfaced 136.45 miles of road, graded 178.09 miles of unsurfaced road, and built 108 bridges.

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[1] Died while this book was in press.

Road Funds

During 1917, about $1,300,000 will be available for the State highway commission, about $393,500 for county road work, and about $130,000 from road bonds.

[Approved by JAMES A. FRENCH, State Engineer.]

NEW YORK

State Aid Legislation

The State commission of highways consists of a single commissioner who is appointed by the governor with the consent of the senate for a period of five years.

The commissioner of highways appoints a secretary, auditor, and three deputy commissioners. Each of the deputy commissioners has had practical experience in the actual building, construction, and maintenance of highways and is familiar with the operations and effect of State statutes relating to highways and bridges.

The first deputy is a practical civil engineer, whose duties relate to the plans, specifications, and execution of all contracts awarded by the department.

The second deputy's duties relate to the maintenance of State and county highways, and the third deputy's duties relate to the improvement and maintenance of town highways and bridges. The commissioner has general supervision of highways and bridges constructed or maintained in whole or in part by the aid of State money; aids district, county, and town superintendents by advice and information; investigates methods of road construction and maintenance; compiles statistics, including highway map of the State; holds public meetings, etc. The State is divided by the commission into not more than nine divisions, each in charge of a division engineer who, under the direction of the commission, makes surveys, plans, specifications, and estimates for the construction and maintenance of highways in his division constructed wholly or in part by the aid of State money. All State and county highways on which the State expends money are inspected annually and a report prepared showing their condition, the improvements necessary, and the estimated cost, and a report made annually to the legislature setting forth the amount required for maintenance for the ensuing year.

The highways of the State are divided into four classes, viz: State highways constructed or improved solely at the expense of the State; county highways improved at the joint expense of the State and county; town highways improved by the towns with

State aid; and county roads constructed by the county without State aid. The State and county improved highways are maintained almost entirely at the expense of the State, each town paying toward such maintenance the nominal sum of $50 per mile for each mile or fractional part thereof, of the improved State and county highways within the town boundary. The maintenance of town highways is included in the term "construction." The expense of maintaining county roads is a county charge.

The system of State highways is defined in the highway law, and the routes described. The system of county highways is designated on the map which was approved by the legislature of 1907, and is subject to modification by the board of supervisors of each county. The cost of improvement of State highways is provided by funds obtained from the sale of State bonds. The State share of the cost of inprovement of county highways is secured from the same source. The balance of the cost of county highways is borne by the county. The board of supervisors of a county may petition for the improvement of any county highway designated on the approved map. If the State commission of highways approves the request, the division engineer prepares plans and specifications which are then sent to the county superintendent, and upon his approval thereof, they are forwarded to the commission for approval, after which they are submitted to the board of supervisors for final approval and appropriation of the county share of the cost. The commission may then advertise for proposals, award contracts, and carry on the work of improvement. The plans for State highways are prepared by the division engineer, approved by the county superintendent, and finally adopted by the commission, and the work carried on in the same manner as that of county highways.

After the final payment under any contract the State commission files a statement of cost with the county treasurer, who thereupon pays upon the request of the commission the county's share as follows: 2 per cent of the cost of each $1000 of assessed valuation of real and personal property in the county for each mile of public highway in such county, not to exceed 35 per cent of the cost for the county. The maintenance of State and county highways is under the direct supervision of the commission, which also has authority to provide for a system of patrol of highways, the patrolman to be appointed by the State commissioner of highways.

The State contributes to town highways on the following basis: (1) Where the assessed valuation of the town is less than $5000 for each mile of highway in such town, outside of incorporated villages, an amount equal to the amount of taxes raised for highways; (2) where the assessed valuation is $5000 or over and less than $7000 per mile an amount equal to 90 per cent of such taxes; (3) where the assessed valuation is $7000 or over and less than $9000 per mile an amount equal to 80 per cent of such taxes; (4) $9000 or over and less than $11,000, an amount equal to 70 per cent; (5) $11,000 or over and less than $13,000, an amount equal to 60 per cent; (6) $13,000 or over, an amount equal to 50 per cent. No town shall receive in one year an average of more than $25 per mile for the total mileage of roads outside of incorporated villages, and the amount which is raised by local taxation shall be such as will, when added to the amount received from the State, be not less than $30 for each mile of highway in the town.

A State bond issue of $50,000,000 was authorized in 1906 and an additional State bond issue of $50,000,000 in 1912. The bond issue was originally intended for the improvement of a system of county highways aggregating 8,380 miles, and to this was added a system of State highways aggregating 3,617 miles. The recent $50,000,000 bond issue is to be expended as follows: $20,000,000 for the construction and improvement of State highways and $30,000,000 for the construction and improvement of county highways. The apportionment among the counties is on the basis of population, the measured mileage of public highways outside of cities and villages, and the total area, each factor having a weight of one-third. Direct appropriations are made by the legislature for maintenance.

Local Road Legislation

New York has a rather centralized system in that the State highway commission, by reason of its extending aid to counties and townships, exercises a limited supervision over practically the entire road mileage of the State. In the counties the governing body is the board of supervisors, and in the townships the township board. The county superintendent of roads is appointed by the county board of supervisors, but in the event they fail to make such appointment, then the State highway commission makes the appointment or includes the county in a district and appoints a district superintendent. The term of office of the superintendent is four years, but he may be removed by the State highway commission upon written charges. Such superintendent is subject to the rules and regulations of the State highway commission. The towns elect biennially a town superintendent of highways who has supervision of the highways therein, subject to the regulations of the State highway commission. The State grants aid in the construction and maintenance of practically every type of road in the State, and the various road officials conduct their work in accordance with the regulations prescribed by the State highway commission.

Local Bond Legislation

The county board of supervisors may, by resolution, authorize the issuance and sale of bonds for paying the county's share of the cost of any highway. These bonds must not be sold for less than par, and the amount of the issue must not increase the total county indebtedness to more than 10 per cent of the assessed valuation.

For the purpose of purchasing toll roads and bridges, the county board may issue bonds which shall bear interest not exceeding 5 per cent, shall run not longer than twenty years, and shall not be sold below par.

Towns may issue bonds for road purposes when authorized by the county board of supervisors. In the case of towns, a majority vote may increase the amount of issue to one-third of the assessed valuation of the town.

Convict Labor Legislation

The town superintendent with the consent of the town board may request the supervisor of the town under the provisions of section 93 of the county law to procure the services of the prisoners serving in the county jail for general work on the public highways of the town.

The board of supervisors of a county, or the town board of a town in which any portion of a county or State highway is situated, may, on behalf of such county or town, present proposals and be awarded a contract for the construction or improvement of such highways, in accordance with the provisions of law. If such contract be awarded to a board of supervisors or a town board, such board shall, by resolution, designate some suitable person, or persons, to carry into effect such contract and to transact all necessary business in respect thereto, and such board may, by resolution, direct the person, or persons, so designated to apply to the superintendent of State prisons for convict labor in the construction of such highway or section thereof. The resolution shall specify the maximum number of convicts to be applied for. The superintendent of State prisons shall detail for labor, pursuant to such resolutions and requests, such number of convicts as shall be available therefor not exceeding the number applied for. Such convicts shall be in the immediate charge and custody of the officers and guards detailed by the superintendent of State prisons, and shall at all times be subject to the control of such superintendent, except that the work to be done shall be directed by the engineers and foremen of the State highway department. The expense of maintenance of such convicts shall be paid by the county or town entering into such contract, from funds due thereon to such municipality.

The prison labor commission is authorized to acquire so much land for agricultural and quarry purposes as may be selected by said commission, and transfer prisoners for agricultural purposes, and to be employed in the quarrying and preparation of building and road materials.

Civil Service Law Applicable to Road Officials

The State commissioner of highways shall appoint such resident engineers, district superintendents, clerks, officers and employees as may be required, subject to the civil service law and other provisions of law, within the amount appropriated therefor, unless the appointment of such clerks, officers, or employees is otherwise provided for by law. District superintendents, appointed as provided in this chapter, shall be appointed from lists prepared from examinations which shall test their qualifications for the actual construction and maintenance of highways and their executive capacity, rather than their scientific attainments. Clerks, other than those employed in the principal office of the commissioner of highways, inspectors, and other employees in the department, whose duties pertain to the maintenance of highways, shall likewise be selected from lists prepared from examinations, testing their general knowledge of the highway law and of the practical construction of highways. Inspectors of construction, other than engineers and levelers, shall be selected from lists similarly prepared, except that they shall be residents of the county within which the highway constructed or improved is located. To the end that the employees of the department of highways engaged in the work of constructing, improving, or maintaining highways under the provisions of this chapter may be practical highway builders, the commissioner of highways is authorized to indicate to the civil service commission the relative value which should be given to experience and scientific attainments. The commissioner of highways, subject to the provisions of civil service law, may remove the division engineers, resident engineers, district superintendents, clerks, officers and employees of the department.

Automobile Registration

The law provides for annual registration with the secretary of State. The schedule of fees is as follows: 25 h.p. or less, $5; 26 to 34 h.p., $10; 35 to 49 h.p., $15; 50 h.p. and above, $25; all motor vehicles used for commercial purposes only, $10 to $70, according to combined weight of truck and rated carrying capacity; passenger omnibuses operating wholly in a municipality, $10; passenger omnibuses operating outside municipalities, $15 to $67.50, according to carrying capacity; dealers and manufacturers, $15; chauffeur's license, $5; motor cycles exempt.

The secretary of State receives all fees from registrations, fines and forfeitures in the first instance. Fifty per cent of the money so received is turned over to the state treasurer and is used by the State commission of highways for the repair and maintenance of State and county improved highways. The remaining 50 per cent is distributed among the counties in which the fees were collected, each county thus receiving 50 per cent of the total fees paid by residents of that county. The moneys received by the counties are used for the permanent construction or improvement of town highways only in said county. The city of New York receives 50 per cent of the total amount of fees collected in that city, in the same manner as the counties receive their proportionate share.

Highway Officials

State Commissioner of Highways.—Edwin Duffey; first deputy commissioner, H. Eltinge Breed; second deputy commissioner, Fred W. Sarr; third deputy commissioner, Benjamin J. Rice; auditor, Sephrine D. Gilbert; secretary, Irving J. Morris; assistant secretary, Frank R. Pennock.

Progress Report

During 1916, contracts were awarded for 667 miles of State and county highways, for which the State appropriation was $6,902,930.81, the county appropriations $2,321,029.89 and the village appropriations $621,550, a total of $9,845,510.

During 1916 379 miles were completed and officially accepted and 136 miles were completed but not accepted, a total of 551 miles built during the year. There were 935 miles of unfinished road under contract on January 1, 1917.

The designated State and county highway systems have a total length of 11,988 miles, of which 7778 miles are completed or under contract.

Road Funds

A bond issue of $50,000,000 was voted in 1906 and another in 1912; $85,000,000 of these issues have been spent or are obligated. The department will request the legislature to make an appropriation of not to exceed $5,000,000 for 1917. In addition, the legislature has been requested to provide $4,500,000 for maintenance and repair of county highways improved by State aid. Forty thousand dollars will be requested for the maintenance of roads within Indian Reservations; $1,945,000 for the maintenance and improvement of town highways. It is expected that about $3,500,000 will be raised by the towns and counties for local road work. The total highway expenditure for 1917 is estimated at about $14,000,000.

If the State of New York accepts federal aid, an appropriation for that purpose will be made on the part of the State to the extent of about $250,000, which, with a similar amount contributed by the federal government will make a total of upwards of one-half million dollars for the improvement of postal routes and main thoroughfares.

[Approved by IRVING J. MORRIS, Secretary State Commission of Highways.]

NORTH CAROLINA

State Aid Legislation

In 1915, the legislature passed an act creating a State highway commission "to assist the counties in developing a State and county system of highways." It consists of the governor, three citizens from the eastern, middle and western parts of the State respectively, the State geologist, a professor of civil engineering of the University of North Carolina, and a professor of the North Carolina Agricultural and Mechanical College. They serve for four years and their actual expenses are paid. The commission appoints a State highway engineer for a term of six years.

The road officials of any county may call on the State highway engineer for advice on any road and bridge problem, in which case he makes the necessary surveys, plans, specifications and estimates for them. If the work is carried out, it must be constructed according to these plans; if it is not carried out, the county must reimburse the State highway commission for its expense in furnishing the information. The State highway engineer must also "supply technical information regarding roads to any citizen or officer in the State." He must prepare plans, specifications and estimates for a system of roads connecting the county seats and principal cities and make traffic censuses. The commission is required to coöperate with county commissioners in educational work concerning the value of good roads.

Local Road Legislation

In some counties the roads are under boards of county commissioners, in other counties they are under the township authorities, but in most counties they are subject to special laws. Road taxes are worked out.

Local Bond Legislation

Upon presentation of a petition by not less than one-fourth of the qualified voters of any township to the board of county commissioners, the board shall within thirty days order an election in the town to determine if bonds shall be issued. This election shall be held subject to the rules and regulations of the general election laws of the State, and a majority vote of the qualified voters shall be necessary. Such elections shall not be held oftener than every twelve months. The amount of bonds that may be so issued shall not exceed $50,000 for any one township in any county, and the bonds shall be paid by the township for which they are issued, and shall not be chargeable against any property or polls outside of the township. These bonds shall be coupon bonds, shall bear not to exceed 5 per cent interest, and shall be sold for not less than par value, and the interest and sinking fund charges shall be met by appropriate annual taxation. The fund raised by this taxation in excess of the amount required to pay interest shall be safely invested by the board of commissioners and the county commissioners are authorized to purchase any of these bonds to the amount of this excess annually, and after ten years they may purchase at a sum not exceeding par value, one-twenty-fifth of the bonds issued for any township.

Convict Labor Law

In counties having arrangements for working convicts upon public roads, the presiding judge shall sentence the following convicts to such work: All those convicted of crimes, the punishment of which is imprisonment in the county jail; those convicted of crimes the punishment of which is confinement in the State penitentiary not exceeding ten years; those sentenced to imprisonment in a county jail by a magistrate.

It is expected that over 2500 men will be available for road work in 1917.

Automobile Registration

The law provides for annual registration with the secretary of State. The schedule of fees is as follows: 25 h.p. or less, $5; 26 to 40 h.p., $7.50; 41 h.p. and over, $10; motor cycles, $2; manufacturers and dealers, $10.

The registration revenue shall be paid into the State treasury and a separate account kept of it. On July 1, of each year, 80 per cent of such revenue shall be returned to the county from which collected for expenditure upon the public roads of such county and for no other purpose. A bill has been introduced into the general assembly to use the automobile tax for highway maintenance under the supervision of the State highway commission.

Progress Report

The commission assisted 65 counties in their road work and prepared plans and specifications and assisted in the construction of a large number of bridges in 1916. These bridges mostly replaced structures destroyed by heavy floods in July.

Road Funds

The State appropriates $10,000 a year for the State highway commission, but a bill has been introduced into the general assembly increasing this to $75,000.

For the 1917 road fund it is estimated that about $2,750,000 will be received from property and poll taxes, $2,300,000 from bond issues, and $200,000 from automobile and dog taxes and other sources, making a total of $5,250,000.

Highway Officials

State Highway Commission.—Governor Thos. W. Bickett, Benehan Cameron, E. C. Duncan, Prof. T. F. Hickerson, Prof. Joseph Hyde Pratt, Prof. W. C. Riddick and Guy V. Roberts. W. S. Fallis is State highway engineer. The commission's office is in Raleigh.

Approved by W. S. Fallis, State Highway Engineer.]

NORTH DAKOTA

State Aid Legislation

At the general election on November 3, 1914, an amendment to the constitution was adopted, providing that the State may grant aid in the construction and improvement of public highways.

The State law provides that inmates of the State penitentiary may be used upon the public highways. However, no convict labor has been used, for the reason that all of the convicts are needed to keep the regular industries of the penitentiary in operation.

The members of the State highway commission, consisting of the governor, the State engineer, and one other member to be appointed by the governor, serve without extra compensation. It is their duty to prepare plans and specifications and superintend the construction of any roads, when requested by any board having jurisdiction over such roads, and to give advice, assistance and supervision with regard to road construction throughout the State, as time and conditions permit, and as the rules and regulations of the commission may prescribe; to have prepared maps of the various counties showing the roads and location of bridges and culverts, and showing roads on which is is proposed to utilize State funds whenever such funds may be available. They shall also issue bulletins containing advice and suggestions, and the law concerning highway construction, from time to time, as they shall deem practicable.

It is the duty of the State engineer, when requested by any board of county commissioners or township supervisors, to prepare plans for the construction of any bridges or culverts, or to examine and report on existing bridges or culverts, charging to the county or township for which such work is done, the actual and necessary expenses and the cost of the work.

At the time of going to press the legislature was considering two bills greatly changing the State road laws.

Local Road Legislation

Under the North Dakota highway laws, in counties having no civil township organization the county board of commissioners act as a highway board; in organized townships the authority is vested in the board of supervisors. In localities where there is unorganized territory the county commissioners may create as many road districts as in their judgment is deemed expedient, and may appoint for each district an overseer of highways. At the first meeting of a township board, succeeding the annual town meeting, it shall appoint for one year a township overseer in direct charge of the construction and maintenance of highways. In unorganized territory the district overseer of highways shall have the same powers and duties as township overseers of highways in organized townships. In counties having a county superintendent of highways the township road overseer shall be ex-officio deputy county superintendent of highways for his respective township. A law was passed in 1915 creating a board of highway improvements in each county, consisting of one member from each road district, which is required to formulate plans and methods for the uniform working and establishing of highways within the county. Such methods as they adopt must be followed in each of the districts in said county.

Local Bond Legislation

Section 183 of article 12 of the constitution authorizes counties, townships, cities, towns, or other political subdivisions to create an indebtedness not to exceed 5 per cent of the assessed valuation of the taxable property therein, but apparently there has been no general statutory enactment permitting the creation of an indebtedness for road purposes under authority thus conferred.

Convict Labor Laws

The board of control is authorized to employ upon the public highways, under the supervision of proper guards, all the convicts not needed in the State twine plant and other established penitentiary industries. They may also be employed by the several counties of the State for work on the public roads thereof when it is mutually so agreed by the county commissioners and the State board of control, the county paying all the salaries and expenses in connection with said work. The convicts shall at all times be under State control, and shall be supervised by skilled laborers who shall at the same time act as guards. As nearly as practicable, all the men shall be pledged on their word of honor not to attempt to escape, they shall be dressed uniformly, and shall bear some insignia not too conspicuous, and shall not be required to work more than ten hours in any one day. Also, a convict shall not be assigned to work in the community from which he came.

The convicts are entitled to a credit of from 10 to 25 cents per day, the exact amount depending upon the amount and manner of work done, and in addition thereto, those assigned to outside work are entitled to a double allowance of "good time."

Automobile Registration

The law provides for annual registration with the secretary of State. The registration fee for all motor vehicles is $3.

The net registration revenue is returned to the county from which collected for expenditure for repairs and maintenance of the main traveled roads of the county, provided that no part of said funds shall be expended within the limits of an incorporated town or city, nor within any township that does not levy a road tax of at least 6 mills on the dollar of assessed valuation. (Chapter No. 6, Laws, 1911.)

Progress Report

During 1915 the State engineer issued standard specifications to a number of counties, and engineering services were performed for several counties. Plans and specifications were also prepared for a $20,000 bridge undertaken mainly by private subscription. It is estimated that during 1917 over $2,700,000 will be spent for roads and bridges.

Road Funds

In addition to funds secured by automobile and motor cycle licenses, the highway maintenance funds are secured by means of a poll tax of $1.50 and a property tax of not to exceed 4 mills on the dollar for bridges and not to exceed 5 mills for highways. In each county having a population of 2000 or more, according to the latest United States or State census, there is levied a property tax of not less than 0.25 mill nor more than 4 mills, which is kept in a distinct fund known as the county road fund and is spent in highway improvement under the direction of the county commissioners. This fund is in addition to all other taxes for highway purposes and is expended only in grading, ditching and surfacing the principal county thoroughfares for which the means otherwise provided are not, in the opinion of the county commissioners, sufficient.

The electors of each township have power at their annual meeting to vote to raise such sums of money for the repair and construction of roads and bridges as they shall deem expedient, provided, that the amount of tax for road purposes shall not exceed 8 mills on the dollar, and the tax for bridge purposes shall not exceed 2 mills on the dollar.

Highway Officials

State Engineer.—Jay W. Bliss, Bismarck.

Highway Commission.—Lynn J. Frazier, Bismarck; C. A. Grow, Minot; Jay W. Bliss, Bismarck.

[Approved by JAY W. BLISS, State Engineer.]

OHIO

State Aid Legislation

There is a State highway department to afford instruction, assistance and coöperation in the construction, improvement and maintenance and repair of the public roads and bridges of the State. It is under a State highway commissioner, appointed by the governor for four years, who appoints three deputy highway commissioners, all required to be civil engineers and one of them designated by him as chief highway engineer. One deputy has charge of road construction, another of road maintenance and repair, and the third of bridges and culverts. The State highway commissioner also appoints as many division engineers, superintendents, inspectors, clerks and other assistants as the work requires.

The State highway commissioner supervises the construction, improvement, maintenance and repair of inter-county highways and main market roads, including their bridges and culverts. Seventy-five per cent of the State highway improvement fund is spent on inter-county highways, and is equally divided between the counties; 25 per cent is spent on main market roads and must be spent so as to distribute equitably the benefits from such expenditure to the different counties. The inter-county highways have been designated by statute and by the State highway commissioner; the main market roads form part of these highways and were similarly designated.

The State highway commissioner advises county commissioners on road construction and maintenance. Plans for bridges costing over $10,000 on county and township roads must be approved by him, and he prepares plans for constructing and repairing any highway bridge when requested by local authorities. Tests and investigations of road and bridge materials are made for him by the Ohio State University. He is responsible for the maintenance and repair of all roads and bridges built with State aid or taken over after construction.

The legislature in session when this book went to press was expected to make material changes in the highway laws.

Local Road Legislation

The improvement of roads in a township is under its board of trustees, but the plans and specifications must be provided by the county highway superintendent, who is also the county surveyor, and the work must be done under his supervision and all payments for it must have his approval. Each township has one to four road districts, with a township highway superintendent in each, appointed by the trustees; he has control of township roads under the direction of the trustees, but also reports annually to the county highway superintendent and must comply with all regulations of the latter not in conflict with instructions from the trustees.

The location, alteration and vacation of all roads in a county, except inter-county and main market roads, are under the county commissioners. The latter also have power, when petitioned by over half of the owners of property taxed for the improvement, to construct, reconstruct, repair or maintain new or existing roads; they can also undertake such work without petition by unanimous vote. Plans and specifications must be prepared for such work by the county surveyor.

A county road improvement may be extended through a municipality with the consent of its council, if the municipality will pay a part of the cost.

The county highway superintendent has general charge, subject to the regulations of the State highway department, of the construction, improvement, maintenance and repair of all bridges and State, county and township highways in the county. He may be removed by the State highway commissioner for incompetence or neglect, and may call on the State highway commissioner for advice and assistance.

When 40 per cent of all roads in a county have been improved with gravel, broken stòne, slag, brick, cement or bituminous materials to a standard approved by the State highway commissioner and the county commissioners make an appropriation for constructing or improving inter-county roads, they may apply to the State highway commissioner for State aid. This is then furnished to an equal amount by the State highway commissioner from the county's apportionment of any road funds in the State treasury, but must be spent in accordance with plans approved by the State highway commissioner. The work is advertised and let by the State highway commissioner. The local contribution of 50 per cent of the cost of roads thus built is subdivided into 25 per cent from the county, 15 per cent from townships and 10 per cent from special assessments. When the local contribution exceeds the county's apportionment of State aid funds, the distribution of costs is adjusted by mutual agreement.

No load exceeding 3400 pounds, inclusive of the weight of the vehicle, shall be carried by a vehicle. Anybody driving on an improved road a traction engine with tires equipped with lugs, spikes or other projections seriously destructive to the highway, shall be fined not less than $10 or more than $200 for each offense.

Local Bond Legislation

If the township road tax is inadequate to meet expenses for road construction and repair, bonds to supply the funds lacking may be authorized by a majority vote of the electors of the township. The bonds may not bear over 6 per cent interest or run longer than 10 years, and may be issued in denominations of $100 to $1000. The payment of principal and interest is met by taxation in addition to the general township tax, subject to the limitation on the combined maximum rate for all taxes.

Townships may issue 5 per cent 10-year bonds in anticipation of taxes to pay for quarries, gravel pits and equipment for working them.

County road bonds running not more than 10 years and bearing not more than 5 per cent interest may be issued by the county commissioners in anticipation of taxes and assessments, but they cannot be sold for less than par. The proceeds are restricted for use on the improvement for which they are issued. Five per cent county road bonds running five years may be issued in anticipation of taxes and assessments to meet the local share of roads built with State aid, but the total issue must not exceed 1 per cent of the county's tax duplicate.

Convict Labor Laws

State convicts may be used on State aid roads or in preparing materials for the roads. The prison authorities prepare the regulations for the government of the convicts, but the work and the manner of doing it are under the control of the State highway commissioner. The latter pays the transportation, maintenance and guarding expenses plus an amount to each prisoner's credit for his work. County commissioners may also employ State convicts on the same terms, and may also employ prisoners in county jails and workhouses, at a rate agreed upon between the commissioners and the prison authorities. Convicts and prisoners may also be used on contract work.

Road Funds

The board of trustees of a town may levy a tax not exceeding 3 mills annually for improving, maintaining or repairing roads. A 2-mill tax may also be levied for township contributions to the cost of roads built with State aid. A township tax may be levied for acquiring quarries and gravel banks.

County road expenses are met in eight ways. 1. From 35 to 50 per cent of the cost of an improvement may be taken from proceeds of general county taxes, from 25 to 40 per cent from the proceeds of county road taxes, and the balance raised by special assessment on a two-mile strip of land. 2. From one-half to two-thirds of the cost may be taken from the proceeds of county road taxes and the balance raised by special assessment on a two-mile strip. 3. Any part of the cost may be raised by special assessment on abutting property, the balance to be paid by the county and townships. 4. Any part may be raised by special assessment on a two-mile strip and the balance paid from county funds. 5. The entire cost may be met by special assessment on a two-mile strip of land. 6. The entire cost may be raised by special assessment on a four-mile strip. 7. Not over half the cost may be paid out of the proceeds of the county road taxes and the balance raised by assessment on a one-mile strip. 8. The entire cost may be met by special assessments on a two-mile or four-mile strip, as the petitioners request; or not over half the cost may be raised by special assessment on a one-mile strip and the remainder may be taken from the proceeds of county road taxes. By unanimous vote the county commissioners may pay the entire cost of an improvement from county road funds, or may agree with the authorities of townships in which the improvement is made for a division of the expenses. The county road tax must not exceed 2 mills and the total taxation must not exceed the limitation on the combined maximum rate for all taxes. The county may also levy a tax not exceeding 3 mills on the property in each township in which a county road improvement is made, for the purpose of meeting the township's share of the cost. The county may also levy a 1-mill tax for its contribution to roads built with State aid.

One-half the funds from automobile registration are used for maintaining the inter-county highways and one-half for maintaining the main market roads.

An annual tax of 0.3 mill is levied to furnish the State highway improvement fund and is outside the limitation upon maximum combined taxes.

Automobile Registration

Automobiles are registered with the secretary of State, the annual fees being: motor cycles, $2; electric vehicle, $3; gasoline or steam vehicle, $5.

Highway Officials

State highway commissioner, Clinton Cowen; deputy commissioner in charge of construction, H. M. Sharp; deputy commissioner in charge of bridges, John R. Chamberlin; deputy commissioner in charge of maintenance, A. H. Hinkle; chief clerk, H. L. Hastings; secretary, M. L. Freeman.

[Approved by CLINTON COWEN, State Highway Commissioner.]

OKLAHOMA

State Aid Legislation

The State department of highways is under the charge of the State commissioner of highways. He is required to furnish without charge to any road official standard plans and specifications for roads and bridges, to report on plans and specifications submitted by any road official, to compile statistics of the roads in the State, to establish in each county standards for the construction and maintenance of its roads and bridges, and to advise with State and municipal authorities on water and sewerage projects. With the consent of the governor he appoints a State engineer and an assistant State engineer.

The State aid roads are designated originally by the county officials, and the State and counties contribute equally toward their cost.

Local Road Legislation

The board of county commissioners of each county must appoint a county engineer, who must pass an examination held for the State department of highways by a board composed of three disinterested civil engineers. One person may serve as county engineer for two or more counties. The board of county commissioners selects from 10 to 15 per cent of the total mileage of roads connecting principal market points in the county and joining similar roads in adjacent counties, to serve as State roads. This system of State roads is examined by the commissioner of highways, and only such portions as are approved by him are adopted as State roads. If any county fails to designate such a road system, the commissioner of highways has power to do so. The surveys and plans for these roads are prepared by the county engineer. All bridges and culverts must be permanent and approved by the department of highways.

Other roads are under the township officials. When the State roads of a county are finished, township roads of an equal standard of construction may be added to the State system. The road work of each township is under a road superintendent, but the plans and specifications must be furnished by the county engineer.

After January 1, 1917, no draft wagon of 2 tons capacity or more, having metal tires less than 3 inches wide, may be sold in the State under penalty of a fine of $5 to $25 for each sale.

All male residents are required to work on roads or pay $5 commutation to the local road authorities.

Local Bond Legislation

The township board may issue bonds in an amount not exceeding 3 per cent of the taxable property upon a three-fifths vote at a special election. The bond interest shall not exceed 6 per cent, and the term shall not exceed twenty-five years. An annual tax shall be levied to pay the interest and to create a sinking fund for the redemption of the bonds at their maturity.

The county commissioners of any county are authorized, upon a three-fifths vote of those voting at a special election, to issue county bonds for building, repairing or acquiring bridges, or building roads surfaced with gravel, stone or other hard material, and the term of the bonds shall not exceed twenty-five years. An annual tax is levied to meet the interest and sinking fund charges on the bonds. All work done under a bond issue must be performed under an engineer designated by the State highway commissioner.

Convict Labor Laws

State convicts are required to be worked on public highways as continuously as possible. The State board of public affairs furnishes tools, machinery and draft animals; the cost of quarters, food, medical attendance and guards is borne by the prison funds; a county using convict labor pays all charges for transportation, feed for animals, board for guards, supplies for machinery, and materials for construction. The State board of public affairs formulates the regulations for governing the convicts and the State corporation commission establishes the transportation rates for the convicts. The State board of public affairs may furnish convicts for county road work, under certain restrictions. In 1916, nine crews with a total of 270 convicts were employed on road work.

Automobile Registration

Motor vehicles are registered with the department of highways. The fee is 50 cents per horse power, A. L. A. M. rating for the first year, 40 cents the second year, 30 cents the third year, and 20 cents a year afterward; dealers' fee, $15. Electric vehicles are taxed on the ad valorem basis. Nine-tenths of the fees are returned to the counties where payment of them was made. The treasurer of each county pays 25 per cent of this money to first-class or chartered cities and the remainder is used as a county road maintenance fund for road dragging and construction of new roads.

Highway Officials

Commissioner of Highways.—George B. Noble. State engineer, Max L. Cunningham; assistant State engineer, W. P. Danford; offices, Oklahoma City. Consulting engineer, Prof. James I. Tucker, Norman.

Progress Report

Between July 1, 1915, and December 1, 1916, a State road system was established in each of the 77 counties and a map prepared showing all State roads. These comprise 14,135 miles out of a total of 112,330 miles of traveled roads. Surveys were made of 5,310 miles at an average cost of $13.86 per mile. There were 3,545 miles of earth roads and 25½ miles of hard-surfaced roads built at a cost of $787,961; 1,743 permanent culverts at a cost of $206,555; and 532 bridges at a cost of $441,472. These figures are not quite complete. Twice as much work is anticipated during 1917.

The State engineer prepared numerous standard plans culverts and bridges and forms for keeping records, and examined the plans submitted by the counties for the work summarized above.

During this period township bonds, aggregating $1,318,500 were voted for earth roads and approved by the attorney general, and $108,500 of bonds of this character were voted but are waiting his approval.

Road Funds

The State collects a property tax of 0.25 mill, the proceeds forming the State highway construction fund, but used by the counties for State roads. Each county may levy a property tax of 0.25 mill for use on roads under the board of county commissioners; any county levying this tax is entitled to receive the money in the State highway construction fund standing to its credit. The townships are authorized to levy a 2-mill tax for road dragging and not over 1½ mills for construction. The quarter-mill tax for State roads has proved inadequate and private subscriptions have been made to enable the work to proceed.

Another source of revenue is a "gross production tax" of 0.5 per cent. of the gross value of asphalt and various designated ores and 3 per cent. of the gross value of petroleum and natural gas produced in the State. One sixth of the returns of this tax is given to the counties where the minerals or oil are produced for aid in building permanent bridges and roads with a surface of gravel, rock or other hard material.

During 1916 the net automobile funds remitted to the counties were $517,137 and about $267,000 was furnished for road work by the gross production tax, in addition to the proceeds of the quarter-mill tax.

[Approved by W. P. DANFORD, Assistant State Engineer.]

OREGON

State Aid Legislation

There is a State highway commission which consists of the governor, secretary of State, and State treasurer.

The duties of the commission are to determine a system of State roads and to construct the same as money becomes available for that purpose. The State engineer is required to act in an advisory capacity to the county courts of the different counties in the matter of road construction and maintenance, whenever so requested. On request of the county court of any county, the

State engineer must furnish plans and specifications for any piece of proposed road construction, or any bridge, free of all cost to such county. Prior to 1915, there was a State highway engineer, but the office was abolished and the work transferred to the State engineer. There is a strong feeling in favor of the revision of the road laws.

Local Road Legislation

Jurisdiction over roads vests in a county or commissioner's court, and the chairman of the court is county judge. The State has authority to construct and maintain, or assist in construction or maintenance, but no authority to establish a road.

Road Bond Legislation

A proposition to issue county road bonds may originate in either of four ways: First, upon the petition of the registered voters equal to one-fourth of the greatest number of votes cast for any candidate for judge of the supreme court at the last general election in that county, or by 5000 registered voters, the county court *shall* submit a proposition to issue county road bonds at a special election called for that purpose; second, upon the petition of one-twentieth of the registered voters, as above, the proposition *may* be submitted at a special election; third, upon the petition of one-tenth of the registered voters, as above, the proposition *shall* be submitted at the next general election; and fourth, the county court *may* submit the proposition at any general election of its own motion.

Upon a favorable vote of the majority of all those voting at the special or general election, the county court shall issue the road bonds or the county warrants in lieu thereof, as funds are needed. The bonds shall be issued in denominations of not less than $50 nor greater than $1000, and shall bear interest not to exceed 6 per cent. The aggregate of all bonds outstanding shall not exceed 2 per cent of the assessed valuation, and shall be sold to the highest bidder. The proceeds shall be expended only in constructing permanent public roads as specified in the order submitting the proposition. A special tax may be levied to pay interest charges, and to provide a sinking fund for the payment of the principal, or provision therefor may be made by transferring funds to such sinking fund.

Convict Labor Laws

State.—The State highway commission may authorize and provide for the construction of any State road or part of such road by convict labor; and if said commission so authorizes and provides convict labor, the governor shall, upon its request detail from the penitentiary such convicts as in his judgment may seem proper for use in the work of constructing said road or part of a road; and such convicts shall be delivered to said engineer on such terms and conditions as shall be prescribed by the parole board and approved by the governor.

County.—Upon the written request of the county court of any county, the governor may detail from the State penitentiary such convicts as in his judgment may seem proper for use on the public highways. Said convicts shall be delivered to any county court on such terms and conditions as shall be prescribed by the parole board and approved by the governor.

Automobile Registration

The law provides for annual registration with the secretary of State. The schedule of fees is as follows: 26 h.p. and less, $3; 27 to 36 h.p., $5; 37 to 40 h.p., $7.50; over 40 h.p., $10; electric pleasure vehicles, $3; electric commercial vehicles, $5; motor cycles, $3.

The net balance of registration revenues on December 31 of each year is returned to the county treasurer of the county from which collected to be credited to the general road fund. Fines and forfeitures are also paid to the county treasury to be credited to the general road fund. There is considerable sentiment favoring crediting automobile fees to the State road fund.

Highway Officials

State engineer, John H. Lewis; chief deputy State engineer, E. I. Cantine. Offices, Salem.

Road Funds

There was $220,000 of State funds available for road work at the opening of 1917. With the money turned over to the State department by the counties for road work, it is expected that a total of $950,000 will be available during the year.

Progress Report

During 1915 and 1916, the State department spent $352,302 of State funds in addition to money contributed by counties on 16 road projects and 23 bridge projects. The small and scattered nature of this work made it difficult to supervise. There is a strong sentiment for more concentrated effort in contrast to the present method of scattering funds on small isolated projects by county courts and supervisors. A manual of cost keeping and accounting and a bridge manual have been prepared for the use of local officials.

[Approved by JOHN H. LEWIS, State Engineer.]

PENNSYLVANIA

State Aid Legislation

The act approved May 31, 1911, and its supplements, provided for the appointment of a State highway commissioner, two deputy State highway commissioners (one of whom must be a competent civil engineer), an auditor, and a chief engineer. These appointments are made by the governor of the Commonwealth by and with the consent of the senate. The State highway commissioner appoints an engineer of bridges; 50 superintendents of highways; and 15 civil engineers, together with a chief clerk, chief draftsman, assistant draftsmen, and a force of clerks and stenographers.

The State highway commissioner was directed to make a survey of all roads of the State and a general highway plan of the State. He collects statistics, publishes maps giving a complete road survey of each county, and may be consulted by county, city, borough, and township officials. He is directed to construct, improve, and thereafter maintain at the expense of the Commonwealth the highways forming the system of State highways, the specifications for which are to be prepared by the State highway department.

The State highway system, which comprises approximately 10,200 miles, is under the exclusive jurisdiction of the State highway department, and comprises the main traveled routes between county seats and principal cities, boroughs and towns, and the main traveled routes leading to the State line. In 1913 a bill was passed creating additional State highways, to become effective June 1, 1915, and another bill making changes in the existing State highways, which became effective the date of approval, July 22, 1913.

Where the expense of constructing a route may be materially lessened by a change of location from that at present defined, the State highway commissioner may, with the approval of the governor, change the location of such a route.

Where a toll-road company controls any part of a route forming a State highway, the State highway commissioner may purchase the toll road at a fair and reasonable price, to be approved by the governor.

State aid is granted for improving State and other highways. Counties, townships, or boroughs (as the case may be), which desire State aid can proceed in the following manner: The township supervisors or commissioners or borough council of the township or borough in which the road lies shall first make petition to the county commissioners, and it shall then be the duty of the county commissioners to adopt a resolution assuming on behalf of the county its share of the cost of the proposed improvement. The county commissioners shall then petition the State highway department for State aid, the cost of the improvement to be prorated among the townships or boroughs (as the case may be), the county, and the State, the State paying 50 per cent of the cost of reconstruction, the county and township, or borough (as the case may be), the other 50 per cent. If either the county, township, or borough desires to act independently of the others, it makes application direct to the State highway department and agrees to assume 50 per cent of the total cost, in which event the other 50 per cent is paid by the State. The State also pays 50 per cent of the cost of maintenance, the other 50 per cent being paid by the township or borough in which the road may lie.

The State aid fund is apportioned among the several counties of the State according to the mileage of township and county roads.

By action of the 1913 legislature, the creation within the State highway department of a bureau of township highways was made mandatory, and the State highway commissioner made responsible for the supervision of all the township highways and bridges constructed and improved, maintained in whole or part by the aid of State moneys; requiring him to prescribe rules and regulations fixing the duties of township officers in respect to all highways and bridges under his jurisdiction; to compile statistics relating to such highways throughout the State; collect traffic census and such other information in regard thereto as he should deem expedient; and call meetings or conventions of township supervisors at such times and places as he deems wise. In addition the State Highway commissioner is responsible for the distribution of bonus funds to townships which are on a cash tax basis; such distribution to equal 50 per cent of the amount of cash tax collected when such 50 per cent would not exceed $20 per mile, this distribution being provisional upon the township treasurer filing a certified copy of bond given by him and an agreement executed covering the proposed expenditure of State money to be received.

In 1913, a maintenance division was established under the direct charge of a maintenance engineer, with a view of standardizing and systematizing of all maintenance work under the jurisdiction of the highway department. This division is now so systematized that the operation of each unit of the maintenance force in the field is reflected in this department immediately upon the expenditure of any money, and each dollar expended is so recorded that the department can locate, by referring to station numbers reported, the 100 feet upon which expended and for what used.

Local Road Legislation

Jurisdiction over local roads vests in boards of county commissioners, and in three supervisors of roads, one elected every other year, in each township and borough. The property road tax is partly rebated to persons complying with the wide-tire ordinance.

Local Bond Legislation

The county commissioners of the several counties may borrow money for improving and maintaining the public roads, and may issue bonds for these improvements. The amount shall not exceed in the aggregate 2 per cent of the total of the assessed valuation of all property in the county at the last triennial valuation; but, no such bonds or indebtedness shall bear interest exceeding 5 per cent. The county commissioners shall not issue bonds in one year to exceed one-half of 1 per cent of the total valuation of all property, as shown at the last triennial assessment; provided, that the amount of bonds issued in any one year in excess of one-tenth of 1 per cent of such total valuation of all property shall be approved by the grand jury and court of quarter sessions.

Convict Labor Law

All male persons sentenced to county jails and workhouses may be assigned to work on public roads of of the county by the prison board. Preference shall be given to the making of new roads and the repair of main roads, all roads to conform to the plans and specifications of the State highway·commission. The work shall be done in 5 mile sections by townships in rotation. Little convict labor was used in 1916.

Automobile Registration

The law provides for annual registration with the State highway department. The schedule of fees is as follows: Less than 20 h.p., $5; 20 to 34 h.p. $10; 35 to 49 h.p., $15; 50 h.p. and over, $20; motor cycles, $3. Motor vehicles with solid tires, less than 4,000 pounds gross, $5; 4,000 pounds and less than 5,000 pounds gross, $10; 5000 pounds and less than 10,000 pounds gross, $15; 10,000 pounds and less than 15,000 pounds gross, $20; 15,000 pounds and not over 24,000 pounds gross, $25; not licensed over 24,000 pounds. Chauffeur's license, $2; dealers and manufacturers for each pair of number tags, $10.

Registration revenue is paid into the State treasury forming part of the appropriation for the construction, maintenance, improvement and repair of State highways and State-aid highways. Fines and forfeitures imposed for violation of the provisions as to speed and weight shall be paid into the treasury of the city, borough, town or townships in which such violations occur for expenditure in construction, maintenance and repair of the highways thereof. Other fines and forfeitures are paid into the State treasury for use in the same manner as registration revenues. Prior to June 1, 1915, the registration fees were used in addition to instead of as part of the State appropriation.

Highway Officials

State Highway Department, Harrisburg.—F. B. Black, State highway commissioner; J. W. Hunter, first deputy commissioner; G. H. Biles, second deputy commissioner; W. D. Uhler, chief engineer; W. R. Main, C.P.A., auditor; Howard W. Fry, chief clerk; W. R. D. Hall,[1] statistician.

Progress Report

This State has a total of 97,850 miles of roads.

There are approximately 2000 miles of State highway routes and State-aid roads, constructed wholly by the State highway department of Pennsylvania in good condition. In addition there are sections of highways constructed by counties and townships independent of the State, information regarding which is not available. There are 416 miles of improved toll roads on State highway routes.

Mileage completed at total expense of State is 943.22 miles on December 31, 1916.

Mileage uncompleted under contract at total expense of State on December 31, 1916, is 25.20.

Mileage of State-aid highways contracted for under the provisions of acts since June 1, 1911, is 164.72 miles and 905.1 miles of State-aid highways were built under the provisions of acts previous to June 1, 1911, making a total of 1069.82 miles completed.

Mileage of State-aid contracts not completed December 31, 1916, is 1.56 miles.

Total miles now being maintained at total expense of State is approximately 10,200.

Of the 1069.82 miles of improved roads built by State aid, about 359.66 miles are not on State highways, and are maintained by the State and township or borough, each bearing 50 per cent of the expense. The remaining 710.16 miles of State-aid highways are on State highway routes and maintained at total expense of the State.

Contracts were let during 1916 for 0.97 mile of telford macadam, 1.59 miles of brick, 0.83 mile of bituminous concrete and 21.8 miles of cement concrete roads, a total of 25.19 miles.

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[1] Resigned while this book was in progress.

Practically all highways are 16 feet wide. Some borough work is wider.

A uniform system of accounts devised by this department likewise has been installed throughout the State, and all necessary books, blanks and forms have been furnished the various township officers.

The first deputy State highway commissioner has direct charge of the bureau of township highways.

During 1916 the maintenance division maintained 8,038 miles of earth, gravel, flint, waterbound macadam, asphaltic bituminous macadam, asphaltic concrete, brick and concrete State highways and 147.2 miles of State-aid highways. Of this total the earth roads were 5,527.2 miles. The forces of this Division also resurfaced 237.7 miles of State highways and 31.6 miles of State-aid highways and treated with various grades of tars and dust-laying oils 965.5 miles of State highways and 167.8 miles of State-aid highways.

Road Funds

The legislature of 1915 appropriated $8,300,000 for the State highway department, divided as follows: For the maintenance and repair of State highways, $6,000,000; for expenses, costs and awards in acquiring turnpikes forming parts of State highway routes, $250,000; for the commonwealth's share in the expense of constructing and maintaining State-aid highways, $500,000; for the rebuilding, repair and maintenance of the National, or Cumberland, road, in Somerset, Fayette and Washington Counties, $50,000; for the payment of a portion of the deficiency caused in 1913 and 1914 in carrying out the laws of the State relative to the construction, maintenance and repair of roads in second class townships, $1,500,000. These appropriations are for the period from June 1, 1915 to June 1, 1917.

An important proviso was included in this appropriation bill which reads as follows: "Provided, That the appropriations made by this Act shall include and not be in addition to the amounts received by the Commonwealth during the two fiscal years beginning June 1, 1915, for the licensing of motor vehicles and drivers, under the Act of July 7, 1913."

The total amount of road taxes collected in cash by second class townships during the year 1914, was $5,699,253.38 and the amount to which they are entitled, viz.: 50 per cent when not exceeding $20 per mile was $1,422,144.34. The total amount distributed during 1916, viz.: $716,681.19 represents a pro rata distribution of 38 per cent of the balance due them for the years 1913 and 1914.

During 1916 the total available funds were $5,416,202. The expenditures were $4,430,476, leaving a balance on January 1, 1917, of $985,726. The expenditures were as follows: payments on contracts, $391,453; engineering, inspection, advertising contracts and applications, $31,404; surveying and plotting State highway routes, $13,002; surveying and plotting county maps, $23,505; maintenance and resurfacing, $3,018,905 for State highways and $339,826 for State-aid highways; machinery, tools and equipment, $74,007; purchase of turnpikes, $80,247; experimental and testing work, $10,610; department and division office expenses, $44,392; traveling expenses, $61,611; contingent expenses, $22,968; departmental salaries, $199,823; bureau of township highways expenses and salaries, $30,461; expenses of automobile license division, $88,263. In addition the department distributed $712,501 as cash tax bonus to second-class townships.

The budget of the department for 1917 and 1918 calls for $24,850,000.

[Approved by W. R. D. HALL, Statistician State Highway Department.]

PHILIPPINE ISLANDS

The governor-general is the administrative head of the insular government. He is ex-officio president of the Philippine commission, which exercises exclusive jurisdiction over territory inhabited by Moros and other non-Christian tribes and forms the upper chamber of the Philippine legislature. The majority of the commission are Filipinos. The secretary of commerce and police, a member of the commission, is in general charge of roads, and the detailed charge is in the hands of the bureau of public works, except for work in Manila and in municipalities which do not request the bureau to take charge. The bureau's work is distributed through 42 districts, each under a district engineer, of whom about one-fourth are Filipinos.

Progress

At the close of 1915 there were 3,068 kilometers of first-class roads with heavy surfacing in the islands, 2,082 kilometers of second-class roads with light surfacing, 3,052 kilometers of third-class or graded and drained roads, and 518.2 kilometers of trails. In addition there were 65.9 kilometers of first-class roads, 114.9 kilometers of second-class roads, 185.2 kilometers of third-class roads and 2,437 kilometers of trails in the department of Mindanao and Sulu.

An attempt is being made to utilize Filipino engineers as rapidly as possible, as a measure of economy, explained in the 1914 report of the secretary of commerce and police as follows: "As most of the employes, other than Filipinos, come from the United States, it is obligatory on the Philippines, economically a poor and undeveloped country, to pay salaries on the United States scale, which is the highest in the world. This is an artificial scale for the Philippines and only adopted because of necessity. It would be an economic crime to apply this very high scale to the remuneration of Filipino engineers or other Filipino employes. They should receive salaries proportionate to the economic conditions of the Philippines."

It was estimated in 1908 that the road needs of the islands could be met by constructing 9,210 kilometers during a period of 17 years. This system is now practically finished, at half the estimated cost and in less than half the estimated time. "This result has been possible mainly because of the immediate, persistent and cordial response of the Filipino people to the propaganda for good roads, to the elimination of elaborate projects, unnecessarily expensive types and widths of roads, and to a high degree of efficiency in organization and methods," according to the insular secretary of commerce.

Road Funds

During 1915, the bureau of public works spent 5,872,057 pesos on roads and bridges, of which amount 1,655,045 pesos was for maintenance. In addition 239,289 pesos were spent on roads and trails in the Mountain province, and 240,050 pesos for construction and 74,747 pesos for maintenance of roads in Mindanao and Sulu.

Automobiles

At the close of 1915, there were about 2,800 automobiles in use in the islands.

Highway Officials.

Director of public works, E. J. Westerhouse; consulting architect, G. C. Fenhagen; chief designing engineer, C. E. Gordon; senior supervising engineer, Mindanao and Sulu, H. F. Cameron; D. E. Henry, acting chief constructing engineer; W. C. West, highway engineer. Main offices, Manila.

PORTO RICO

Road Laws

Under the Foraker Act of 1900, the commissioner of the interior of Porto Rico has charge of all insular public works, and the political code of Porto Rico subdivides his office into various divisions, of which the division of public works is intrusted with highway affairs.

The main roads of the island are 1159 kilometers long. Of this total, 275 kilometers were built by the Spanish government, 141.7 kilometers by the U. S. military government, and 742.3 kilometers by the civil government; the remaining sections have not yet been completed. These roads cross the island in all directions and reach all cities and towns. Most of them are good automobile roads.

Convict Labor Laws

Convict labor is employed throughout the island on road work. The best results are obtained when it is used near towns having an insular jail, as this eliminates the extra expense and inconvenience of guarded camps.

Road Funds

During the fiscal year 1915–1916, $106,656 was spent for new roads and $31,186 for new bridges, and several roads were surfaced at a cost of $7,985. The expenditures for maintenance were $289,174, an average of $257 per kilometer. On roads under municipalities $56,139 was spent for maintenance and $11,904 for new roads and bridges. The legislature of 1916 authorized the sale of $2,000,000 road and bridge bonds, and $500,000 is now available from this source.

The municipalities receive 90 per cent of all regular property taxes, 8 per cent devoted to municipal roads being included.

Officials

Governor, Arthur Yager; commissioner of the interior, Manuel V. Domenech; assistant commissioner, Edmund Enright; superintendent of public works, Guillermo Esteves.

[Approved by Acting Secretary of Porto Rico.]

RHODE ISLAND

State Aid Legislation

The State board of public roads, consisting of five persons, one from each county, is appointed by the governor for a term of five years. The board has direct control of the expenditure of all appropriations by the legislature for road improvement, and has supervision over the construction and maintenance of all State roads.

The entire cost of construction and maintenance of State roads is paid by the State. At the close of 1915 there were 325 miles of State roads under the direct control of the State board. A State bond issue of $600,000 was authorized in 1906 to bear 3 per cent and additional bond issues of $600,000 in 1909 and 1912, for use in completing the system of State roads. No more than one-third nor less than one-seventh of the available appropriation in any year shall be expended in any one county. The proceeds of automobile licenses and fines are used for the repair of State roads under the direction of the State board of public roads.

In addition to the State highways, State aid is granted as follows:

Whenever any town shall make an annual appropriation equal to or in addition to the sum of 20 cents on each $100 of taxable valuation, and whenever the electors shall vote that said appropriation be expended under the direction of the State board of public roads a sum of money equal to one-fifth of the moneys so appropriated by any town is annually appropriated by the State for the care and maintenance of the public highways and bridges of said towns. At the close of 1915 there were 1795 miles of town roads.

In 1912 legislation was enacted providing that bridges on State roads shall be under the control of the State board of public roads.

Local Road Legislation

The local roads are under the town council of the several townships, who usually appoint a highway commissioner to look after the roads.

Automobile Registration

The law provides for annual registration with the State board of public roads. The schedule of fees is as follows: 20 h.p. or less, $5; more than 20 h.p., $10; more than 30 h.p., $15; more than 40 h.p., $25; all commercial vehicles, $7; motor cycles, $1; dealers and manufacturers, $50; operators, including owners, $1.

The revenue derived from registrations, fines and forfeitures is paid into the State treasury to be used for the repair and maintenance of State roads under the direction of the State board of public roads.

Highway Officials

State Board of Public Roads, Providence.—Frank Cole, William C. Peckham, John F. Richmond, Benj. F. Robinson and Abram L. Atwood, members of board; Irving W. Patterson, engineer; Peter J. Lannon, clerk.

Road Funds

Total expenditures on trunk lines for construction to December 31, 1916, $2,214,831.67; total for reconstruction, $669,956.87; total for repairs and maintenance, $783,708.96; total for surface treatment, $39,636.14; total for engineering, $344,763.37; total for tools and machinery, $49,687.14; total for advertising, $8,997.14 total expenditures from 1903 to December 31, 1916, $4,111,581.55.

Receipts from 1903 to December 31, 1916:—Bond issues, $1,800,000.00; appropriations, $914,921.34; automobile law, $1,089,054.67 received from towns for additional width, $88,399.27; special road tax, 1916, $212,298.43; miscellaneous $24,730.68; total $4,129,404.39.

Expenditures for 1916: Reconstruction, $332,115.41; repairs and maintenance, $100,419.58; surface treatment, $1,322.45; advertising, $752.33; tools and machinery, $2,375.24; engineering, $33,563.71; total, $470,548.72. Expenditures on bridges for 1916, $65,102.97.

The Board of Public Roads expects for 1917 a special road tax of $215,000; an appropriation to meet the federal aid law of $35,000 and a like amount from the federal government; automobile law, about $250,000; and from bond issue for bridges, $200,000.

[Approved by PETER J. LANNON, Clerk Board of Public Roads.]

SOUTH CAROLINA

State Aid Legislation

The State does not grant aid and has no highway department but considerable amount of efficient investigative and educational work is done in behalf of road improvement by the State commissioner of agriculture, Hon. E. J. Watson.

Local Road Legislation

Control over the roads is in the hands of the boards of county commissioners, with a county road supervisor or county engineer in immediate charge of the work. Road taxes are worked out. Vehicles with tires over 4 inches wide pay 25 per cent less toll on toll roads than similar vehicles with narrower tires.

Convict Labor Law

Any convict serving a sentence of six months or more, life sentence excepted, in the State penitentiary, or any county jail or upon the public works of any county, shall be entitled to have one-tenth, of such sentence deducted for good behavior.

The county supervisor of each county in the State may be allowed to use any of the convicts he may select, sentenced from his county to the State penitentiary, without charge, for the purpose of working the roads of his county, or for such other purposes as he may deem proper.

Automobile Registration

The law provides for registration with the clerk of court of the county in which the owner resides. Registration for all motor vehicles is $1. No general provision is made for distribution of the revenue from registrations except that in 1914 an act was passed for Oconee County providing that the proceeds of registering motor vehicles therein, after deducting 5 per cent commission for collection, should go into the general road fund of the county.

Road Funds

County road and bridge expenditures during 1916, aside from the value of convict labor, were approximately $1,250,000. A $950,000 bond issue was passed by Greenville county.

[Approved by U. S. Office of Public Roads and Rural Engineering.]

SOUTH DAKOTA

State Aid Legislation

A State highway department was established in July, 1913, consisting of a commission of three members, without salary. There is no provision in the road laws of the State for State aid or control of the highways, no funds being provided. The work of the commission is to give advice and conduct educational work.

At the time of going to press, it was expected the legislature would shortly make some changes in the road laws.

Local Road Legislation

In most counties the roads are under county authorities and township authorities. The road taxes are worked out.

Local Bond Legislation

It is provided in article 25, section 1137, of the revised code of 1903, that the boards of supervisors of organized townships are authorized to issue coupon bonds when directed by a two-thirds majority of the voters, at a town meeting called for that purpose. Under the amendment of 1911, chapter 250, these bonds or orders are to be payable in such amounts and at such times, not exceeding ten years from date, as two-thirds of the legal voters present and voting shall determine, with interest not exceeding 6 per cent per annum, payable annually. The section of the original article agrees with this amendment in its provision that the above action may be taken at an annual town meeting duly advertised.

Section 1139 of the original act provides that the board of supervisors must levy a tax for interest and principal not exceeding 15 per cent of such maturing bonds, and section 1140 of the original act provides that whenever a petition bearing the signatures of two-thirds of the legal voters of a township asks that an amount of money not exceeding 5 per cent of the taxable valuation of the town and not exceeding $5000 be raised for the construction of any public road or roads, the supervisors shall issue and sell coupon bonds for the amount specified. The term shall not exceed twenty years and the interest shall not exceed 10 per cent, payable annually, and these bonds are to be sold for not less than par value. The interest and principal are to be provided for by taxation. Money so obtained is to be used under the direction of the supervisors of the town involved.

Convict Labor Law

When in the opinion of the sheriff any convict sentenced to hard labor can be more profitably employed outside of the jail or yard, it shall be his duty to employ said convict either in work on public streets or highways or otherwise.

Automobile Registration

The law provides for annual registration with the secretary of State. The application for registration shall be filed with the county treasurer and the payment of fees made to him. The schedule of registration fees is as follows: Automobiles, $6; motor cycles, $2.

Twelve and one-half per cent of the gross revenue is transmitted to the secretary of State with the application to be expended in payment of costs in connection with registration. Eighty-seven and one-half per cent of the gross revenue shall be retained by such county treasurer for expenditure only in grading, crowning, draining, dragging, graveling or macadamizing public highways of the county under the direction of the board of county commissioners.

Highway Officials

State Highway Commission.—E. C. Issenhuth, chairman, Redfield; N. O. Monserud, Sioux Falls; B. M. Wood, Rapid City.

[Approved by E. C. ISSENHUTH, Chairman State Highway Commission.]

TENNESSEE

State Aid Legislation

In 1915 a State highway commission was created, consisting of the governor, State geologist, dean of the engineering department of the University of Tennessee, and three members appointed by the governor. The commission is required to prepare a general highway plan of the State, showing the main roads which, when improved, will form a connected system throughout the State; to collect statistics regarding the roads and bridges in the State; and to establish standards of road construction and maintenance for the different counties. The commission may be consulted by county and district road and bridge officers and these officers must furnish it with information concerning the roads and bridges in their charge. This branch of the work has outgrown the resources for carrying it on.

The commission is authorized to execute any agreements with the federal government incident to receiving aid from the latter. A number of laws affecting road work are pending in the legislature.

Local Road Laws

The local roads in a county are under the county court, composed of the county judge and four lay members, who divide the county into road districts and appoint a road commissioner for each. The commissioner may appoint a road overseer for each section of his district. The county court also appoints a board of turnpike commissioners to look after toll roads in the county. If any county does not care for road districts, it may elect a county board of road commissioners, of three members, to have charge of all roads in the county. Many have done so, employing county engineers to have charge of the work.

From five to eight days labor on the roads is required of all male citizens, and in two counties the owners of wagons and teams may be required to give five to eight days' use of them.

Road Bond Laws

Under an act approved September 27, 1913, the county court of any county, when authorized by a majority vote at an election held for the purpose, may issue coupon bonds for highway purposes in any amount which will not increase the outstanding indebtedness of the county to more than 10 per cent of the taxable valuation. These bonds shall bear interest at not exceeding 6 per cent, shall not run for more than forty years, and shall not be sold for less than par; provided that a two-thirds vote may authorize a bond issue that may increase the outstanding indebtedness to an amount not to exceed 15 per cent. The county court provides the levy for interest and retiring the bonds and also for creating an annual maintenance fund equal to 2 per cent of the bond issue.

In case of federal aid, the court is authorized to appropriate an amount not to exceed double the federal aid, and, in case there are insufficient funds in the treasury, may issue bonds not to exceed 3 per cent of the taxable valuation.

Convict Labor Laws

County convicts may be worked upon the public highways of the county, subject to the direction of the county court. State and county convicts may be worked by the State highway commission. In 1916, 400 convicts were used in road work; the counties pay $1 per day for each convict.

Progress Report

The department has established with the automobile funds a patrol system of maintenance in 24 counties. A patrolman is paid $50 a month. He furnishes a one-horse wagon and the county furnishes the tools and materials. The department placed a bituminous surfacing on 200 miles of road. The bituminous material was purchased under a general contract by the department, as the agent for the counties, which bought the equipment for applying it.

Automobile Registration

Motor vehicles are registered with the secretary of State. The fees are $5 for automobiles for four persons or less, auto trucks and traction engines, $7.50 for automobiles for more than four persons, $2.50 for motor cycles, $1 for registration of license with clerk of county where owner resides, $10 for dealers. Ten per cent of the proceeds are reserved for the maintenance of the State highway commission and the remainder forms a State highway fund spent under the direction of the State highway commission for the maintenance of roads in the several counties in proportion to the registration fees collected in them.

Highway Officials

State Highway Commissioners.—Governor Tom C. Rye, Dean Chas. E. Ferris, Dr. A. H. Purdue, Arthur Crownover, W. H. Crox and Chas. F. Williams. Secretary, J. J. Murray; State highway engineer, A. M. Nelson; Bridge engineer, L. W. Erickson; Division engineers, J. A. Reagan, W. P. Butler and R. C. Fergus; Chief clerk and statistician, O. M. West. Offices, Nashville.

Road Funds

In 1916 about $200,000 of State funds was spent under the direction of the department for maintenance, together with $600,000 raised by public bodies and private parties. The county road and bridge taxes furnished about $1,500,000, special county appropriations furnished about $1,000,000, and about $10,000,000 has been raised or is pending by bond issues.

If pending legislation carries, a 1-mill tax will furnish about $700,000 for cooperative work under the federal aid road law. The amount available under the first two federal appropriations is about $342,000. The automobile fees for 1917 are estimated at $250,000.

[Approved by J. J. MURRAY, Secretary, State Department of Highways.]

TEXAS

State Aid Legislation

The State has no highway department and grants no aid to road improvement.

Legislation is pending for a State highway commission of three members, holding office for six years, one commissionership becoming vacant every two years. They are to appoint a State highway engineer. Half of the proceeds of the automobile licenses are to go to a State highway fund and half to the counties where paid. The commission is to designate a system of State highways, upon which the State highway fund is to be spent if the counties agree to contribute an equal or larger sum.

Local Road Legislation

The local roads are under the charge of the county courts. Where a county judge is chairman of a county court he usually appoints the county engineer or superintendent, while elsewhere the court makes the appointment. Road taxes are worked out.

Local Bond Legislation

Any county, political subdivision, or other defined district of the county, upon a vote of two-thirds majority of the resident, property-holding taxpayers, may issue bonds for road purposes in an amount not to exceed one-fourth of the assessed value of the real property therein. These bonds shall run for not less than twenty nor more than forty years, with such option of redemption as may be fixed by the commissioners' court, shall bear not more than 5½ per cent interest per annum, and must be examined by the attorney general and registered by the state comptroller of public accounts. The county commissioner's court shall levy a tax sufficient to pay the interest on these bonds and produce a sinking fund sufficient to redeem them at maturity. Each political subdivision or defined district so issuing bonds shall be made a body corporate, and may sue and be sued in like manner as counties. The county commissioner in whose precinct the political subdivision or defined district is located shall be ex-officio road superintendent of the road district, with power to contract for and on behalf of it.

Convict Labor Legislation

The commissioners court may require all male county convicts, not otherwise employed, to labor upon the public highways under such regulations as may be deemed most expedient. Each convict worked on the roads in satisfaction of any fine and cost shall receive a credit thereon of 50 cents for each day he may labor and reasonable commutation of time may be granted as a reward for faithful service and good behavior, provided same shall not exceed one-tenth of the whole time.

Automobile Registration

The law makes provision for registration with the clerk of the county in which any motor vehicle owner resides. The registration fee is 50 cents. Legislation is pending fixing the fee at 35 cents per horsepower and placing the collection of the money with the State highway commission.

Progress Report

It is impossible to give the improved road mileage of the State, but it is quite large because extensive improvements have been made by counties and road districts in recent years.

Road Funds

There is a county property tax of 15 cents on the $100 for roads and bridges, and a special road tax of the same amount may be authorized by a majority vote of the electors. County road warrants are also issued freely for road and bridge work, but the system is severely criticized.

Over $20,000,000 were spent in highway improvements in 1916, and a larger expenditure seems probable in 1917.

[Approved by J. D. FAUNTLEROY, District Engineer, U. S. Office of Public Roads.]

UTAH

State Aid Legislation

The State road commission consists of the governor, the State engineer, the State treasurer, one member of the faculty of the Agricultural College of Utah and one member of the faculty of the University of Utah, all of whom serve without compensation. The commission designates the roads which comprise the system of State roads; has charge of the expenditure of the State road building fund; furnishes plans, specifications and estimates for culverts, bridges and road construction on application of county commissioners; tests road materials, conducts experiments and investigations with reference to road construction when deemed necessary and prepares and issues a manual of road building and maintenance for information and guidance of public and local officials; keeps all maps, profiles and papers in the office of the commission for public inspection and reference; submits report biennially to the governor.

An appropriation is made from the general revenues of the State as a State road fund. This fund is available for the construction and maintenance of State roads in each county in equal proportions. The law requires counties having an assessed valuation under $2,000,000 to duplicate one-fourth of the amount of the State road fund appropriated by the State for such counties, and counties having an assessed valuation of more than $2,000,000 and less than $4,000,000 to duplicate one-half of the amount, and counties having an assessed valuation of more than $4,000,000 to duplicate the full amount. The State road commission gives notice of intention of road improvement, including amount of money available in State fund for the county, general outline of work, the amount of special tax levy to be placed on property in county not later than June 1 of each year. The county commissioners accept or reject requirements of the State road commission within thirty days of receiving proposal from the latter. In case of acceptance the county commissioners are required to levy the special road tax, which is not to exceed 5 mills on all taxable property within the county, the amount thus realized to be used in connection with the county appropriation and State road building fund but not in lieu of the amount to be appropriated by the county. Should the county default in the payment of its proportion after its acceptance of the requirements, the State road commission is authorized to collect the amount of the default from any moneys due the county in the hands of the State treasurer. If the county commissioners of a county fail to accept the proposal of the State road commission within the time limit specified, the county forfeits its right to its proportion of the State road fund for that year which remains a part of the State road fund to be apportioned the following year.

Where the streets of any city are or become a part of the system of State roads, the city may levy a special tax, not exceeding two mills, to be used in connection with the State road fund on the portion of the State road system within the city and to be expended under the direction of the State road commission.

The State road commission makes all plans, specifications and estimates for the improvements of State roads and awards contracts. State roads are kept in repair by the State road commission.

Local Road Legislation

Jurisdiction vests in elected boards of county commissioners, each of which is required to appoint a road commissioner annually.

Local Bond Legislation

The board of county commissioners may contract bonded indebtedness by an order specifying the purpose for which the indebtedness is to be created and the amount of the indebtedness, and by providing for submission of the proposition to the electors of the county at the next succeeding general election, or at a special election to be called for that purpose. At this election only such qualified voters as have paid a property tax in the county in the year preceding the election shall be permitted to vote on the question of issuing bonds. A majority of those voting shall be necessary to authorize the issuance of bonds. If the bonds are issued, the board shall levy a tax necessary to pay the interest on them and to create a sinking fund for their redemption at maturity. Bonds shall not be in an amount which, including existing indebtedness, will exceed 2 per cent of the value of the taxable property of the county.

Convict Labor Legislation

Convict labor may be utilized in providing road material and also actual construction. Prisoners in the county jail may be required to work on the county roads under regulations made by the board of county commissioners, and prisoners in the State prison may be required to work on the State roads.

When State prison convicts are used in the construction or improvement of any State road, the work shall be under the authority and control of the State road commission, the State board of correction and the warden of the Utah State prison.

The State board of pardons is required to make provision for granting privileges and reduction of sentence for good behavior on part of convicts employed on roads.

Automobile Registration

The law provides for registration with the secretary of State. The registration fees are as follows: $3 for each motor cycle, $10 for each electric motor vehicle used only for pleasure purposes, $10 for each commercial motor vehicle used for carrying passengers for hire, $10 for each commercial vehicle or truck, $5 for every other motor vehicle not exceeding 25 h.p., $10 for every other motor vehicle exceeding 25 but not exceeding 40 h.p., $15 for every other motor vehicle exceeding 40 h.p.; chauffeur's license, $2.

The registration revenues are paid into the State treasury and there credited to the State road fund to be expended under the direction of the State road department.

Highway Officials

State Road Commission, Salt Lake City; Wm. Spry, chairman Richard R. Lyman, vice-chairman; W. D. Beers, Daniel O. Larson, and Wm. Peterson. E. R. Morgan, State road engineer and secretary. The road commission appoints a State agent in each county to take charge of State road work.

Road Funds

An annual appropriation of $100,800 is made from the general revenues of the State for a State road fund. Bonds of the State may be issued for road work.

Progress Report

On December 1, 1916, there were 3,440 miles of State road designated. During 1916, 404 miles were graded, 56 miles surfaced with gravel, 21 miles with shale, 20 miles with concrete, 15 miles with bituminous materials and 12 miles with clay and sand; 34 bridges and 634 culverts were built. The entire length of State roads was maintained.

[Approved by E. R. MORGAN, State Road Engineer.]

VERMONT

State Aid Legislation

The State highway commissioner is appointed by the governor for a term of two years, and has control over the expenditures of all moneys appropriated by the State for highway purposes. He appoints not to exceed one supervisor for each county to assist him in the performance of his duties. The State highway commissioner meets the selectmen, road and street commissioners of the several towns and villages at least once annually, and these selectmen and commissioners receive their per diem and necessary expenses for attending the meetings.

The selectmen and town commissioners select the roads on which State aid shall be expended, but such selection is subject to the approval of the State highway commissioner. The selectmen and the State highway commissioner may agree upon any plan of expenditure deemed best in any such town.

A State highway tax of 5 cents on each $100 is annually assessed and the amount thus derived is apportioned to the towns upon the basis of the road mileage therein, which shall be certified to the secretary of State by the selectmen. A direct appropriation is made to be available to cities and towns, excepting incorporated villages, as follows: When a town shall vote to raise money in addition to the amount required by law, an amount shall be apportioned to the town equal to the excess amount, provided it is not less than $100 or more than $1000 in any one year.

Provision is made for the supplying engineering services on all bridges, and for State aid on the building or rebuilding of bridges of less than 30 foot span. The amount of State aid is not to exceed 25 per cent of the cost of the bridge, and in no case to exceed $300. The appropriation is $15,000 for this purpose.

Provision is also made for towns and State to unite in maintaining certain approved State roads under the patrol system, the town appropriating a proper amount and the State supplying the balance.

Local Road Legislation

One or two road commissioners are elected by the town each year, or they may be appointed by the selectmen, providing the town votes them the authority. The county court annually appoints three persons as county road commissioners.

Local Bond Legislation

Any town or incorporated city may issue bonds to an amount not exceeding three times its grand list for the purpose of purchasing road-making apparatus and building permanent highways therein.

To authorize such bonds a two-thirds majority vote of all those cast at a meeting of the town or corporation for that purpose shall be necessary. These bonds shall be issued for a term not exceeding twenty-five years, with interest coupons attached bearing not to exceed 5 per cent interest. The town, city or village must by vote determine the time, place, manner of payment, and the terms, denominations and conditions of such bonds.

Convict Labor Legislation

The sheriffs of the several counties may employ or cause to be employed able-bodied prisoners confined in county jails, upon conviction for crime, in the improvement of the public highways within a radius of 30 miles from such jail and outside of a city or incorporated village. The county sheriff makes necessary rules for the proper care of such prisoners subject to the approval of the attorney-general and governor. The State highway commissioner shall designate subject to the approval of the sheriff the highways upon which labor shall be employed. The highway commissioner or his assistants shall direct the work.

Automobile Registration

The law provides for annual registration with the secretary of State. The schedule of fees is as follows: First registration, per h.p., $1; second registration, per h.p., 75 cents; third and subsequent registrations, per h.p., 50 cents; operators, including owners, $2.00; manufacturers and dealers, $25.

The net registration revenue is paid into the State treasury to be expended for the repair and maintenance of main thoroughfares and State roads under the direction of the State highway commissioner.

Highway Officials

State highway commissioner, Stoddard B. Bates; clerk, M. E. Shedd; office, Montpelier, Vt.

Progress Report

Of the 15,000 miles of roads in the State, about 4000 miles are selected as State roads to be improved. About $250,000 of State money in addition to that expended by towns, was spent on maintenance in 1916. The plan of improvement is to concentrate the work on the worst places on these 4000 miles of main roads instead of building long stretches of new roads. In this way the main roads have no very poor sections, after the spring thaws are over; 175 miles of road, including cities and villages, were built in this way in 1916 at a cost of $450,000. Gravel roads seem to answer Vermont conditions most satisfactorily.

In 1913 a beginning was made in systematic maintenance by establishing about 70 miles of patrol routes on the trunk roads. These routes were increased to 280 miles in 1914, 445 miles in 1915, and 730 miles in 1916.

Road Funds

For maintenance of the State roads only, there will be expended by the State an estimate of $250,000; expended by the towns, $150,000; total $400,000.

[Approved by M. E. SHEDD, Clerk, State Highway Commission.]

VIRGINIA

State Aid Legislation

A State highway commissioner is appointed by the governor, with the consent of the general assembly, for a term of six years. The commissioner, together with the professors of civil engineering of the University of Virginia, the Virginia Military Institute, and the Virginia Polytechnic Institute, constitute the State highway commission. The State highway commissioner is required to be a citizen of the State and a civil engineer versed in road building.

The State highway commissioner has supervision of the construction and maintenance of main-traveled roads of the State, may recommend to the governor and local authorities needed improvements, collect information and disseminate the same, and give advice.

Whenever the local authorities of any county desire to permanently improve any main road, they may make application to the State highway commissioner, If he approve such application he shall prepare plans, specifications, and estimates and submit a copy of same to the local authorities. If they decide to improve said road, they may make application to the State commissioner for State aid, which may be money aid or convict labor. If money aid is desired, the local authorities shall agree that the county will bear one-half of the cost of improvement and the State highway commissioner shall advertise for bids and the local authorities award the contract subject to the approval of the State highway commissioner. The work shall be done under his supervision. The money aid is apportioned among the counties of the State according to the total amount of State taxes paid by the respective counties. If a county pays more than 50 per cent of the expense it shall be entitled to receive annual apportionment until the receipts from the State shall equal 50 per cent of the cost of such permanent improvement.

If convict labor is desired, the local authorities shall undertake to supply necessary materials, tools, and teams, and have the work done under the supervision of a civil engineer, to be supplied by the State highway commissioner, at a salary not to exceed $1200 a year, to be paid by the county. The State commissioner then makes requisition on the superintendent of the penitentiary for such convicts as he may deem necessary. If the local authorities desire to do the work by contract, the labor of the convicts may be estimated at $1 per 10 hour day, and the State grant in this way not more than 40 per cent of the contract price. Counties may not receive both convict labor and money aid in the same year. Any county may use its apportionment of State money in the construction of bridges, and any county may determine what part of its 50 per cent of the cost of road or bridge construction shall be borne by the sub-divisions of the county.

Whenever any county or district shall issue bonds for road improvement, application shall be made to the State highway commissioner for a competent highway engineer to make plans and specifications and supervise the work, which shall be awarded to contract jointly by the State highway commissioner and the local authorities. The proceeds of automobile fees are expended under the direction of the State highway commissioner.

Local Road Legislation

Jurisdiction over roads vests in the county boards of supervisors. Each board is authorized to appoint a county road superintendent or a road superintendent for each magisterial district or group of districts, or it may appoint both county and district superintendents.

Local Bond Legislation

Upon the petition of a majority of the board of supervisors of any county or upon the petition of 150 freeholders of a county to the circuit court thereof, the circuit court may order an election to determine whether the board of supervisors of the county shall issue county bonds for road purposes. A majority of the qualified voters of the county will be necessary. The amount of the bonds, including all bonds previously issued and remaining unpaid, shall in no case exceed 10 per cent of the total taxable value of the county. These bonds shall be issued in denominations of $100 or some multiple thereof, shall bear not to exceed 6 per cent interest, and shall be payable not exceeding thirty-four years from the date thereof, but may, in the discretion of the board of supervisors, be made redeemable at such time or times as the board may prescribe and stipulate upon the face of the bonds when issued. After the issuance of the bonds, a tax shall be levied in the county on all property liable to State tax to an amount sufficient to meet the interest on the bonds and create a sinking fund for their redemption at maturity.

The board of supervisors, or local county road board if there be one, shall apply to the State highway commissioner for, or shall employ a competent road engineer to make plans and specifications for and supervise the improvements made from the proceeds of the bond issue.

Bonds may be issued by any county for the purpose of macadamizing or otherwise improving the public roads and bridges of any magisterial or road district in such county. Before the bonds are issued, a petition signed by a majority of the board of supervisors of the county or by fifty freeholders of any magisterial district or districts in the county shall be presented to the circuit court of the county, which shall order an election to be held to determine whether the bonds shall be issued. A majority of the qualified voters of the district voting thereon shall be necessary to carry the election. The amount of these bonds shall not exceed 10 per cent of the total assessed taxable values at the time in the magisterial district. These bonds shall be in denominations of $100 or some multiple thereof, shall bear not exceeding 6 per cent interest per annum, and shall be payable within not exceeding thirty-four years from the date thereof, but may, in the discretion of the board, be made redeemable at such time or times and upon such notice as the board may prescribe and stipulate upon the face of the bonds when issued. The necessary tax levy shall be made by the board on all taxable property liable to State tax in the magisterial district, in order to meet the interest on the bonds and to create a sinking fund for their redemption at maturity.

Under a clause in article 5 of chapter 76 of the laws of 1908, when more than 50 per cent of the expense of permanent road improvement in any county is expended in accordance with provisions of the act, that county shall be entitled to receive its annual apportionment of State aid until its receipt from the State on that account shall equal 50 per cent of the expense.

Convict Labor Legislation

After May 1, 1913, all male prisoners confined in the State penitentiary shall be subject to work on the State convict road force, except those considered unsafe by the superintendent. The road force shall be under the direction of a civil engineer appointed by the State highway commissioner, or of a guard so appointed who shall be well versed in road building. When local road authorities desire to make permanent improvement by con-

tract, the State may furnish such force of convicts that at $1 per day will amount to 40 per cent of the contract price.

Automobile Registration

The law provides for annual registration with the secretary of State. Fee for certificate of registration and license is 40 cents per horse power. One-half of this fee is charged after September 1. All fees derived from automobile, garage and chauffeur licenses are paid into the State treasury and constitute a special fund to be expended under the direction of the State highway commissioner in the maintenance of roads and bridges constructed under the supervision of the highway department. The counties are required to put up an equal amount.

Highway Officials

G. P. Coleman, State highway commissioner; Wm. M. Thornton, dean, engineering department, University of Virginia; R. B. H. Begg, dean, engineering department, Virginia Polytechnic Institute; Col. T. A. Jones, professor of civil engineering, Virginia Military Institute; C. B. Scott, assistant commissioner; B. Atkins, clerk; D. McDonald, auditor; S. L. von Gemmingen, maintenance engineer; C. S. Mullen, assistant maintenance engineer; F. D. Henley, A. H. Pettigrew, J. L. Cresap, W. I. Lee, division engineers; E. R. Cocke, Jr., acting division engineer; Wm. R. Glidden, bridge engineer. Offices, Richmond.

Progress Report

Mileage and Cost of Roads Constructed

During Year Ending September 30, 1916

	Miles	*Cost*	*Average cost per mile*
Macadam—Money aid	42.93	$218,216.29	$5083.07
Macadam—Convict labor	55.09	269,534.92	4892.62
Previously graded			
Macadam—Money aid	10.89	37,277.68	3423.11
Macadam—Convict labor	11.33	18,878.65	1,666.25
Bituminous macadam—Money aid	1.88	29,955.98	17,151.82
Bituminous macadam—Convict labor	4.78	38,618.75	8,079.24
Previously graded			
Bituminous macadam—Money aid	3.08	18,116.76	5,882.06
Concrete—Money aid	10.15	113,596.28	11,191.75
Gravel—Money aid	31.93	92,705.70	2,903.40
Gravel—Convict labor	18.38	38,175.82	2,077.03

Mileage and Cost of Roads Constructed—continued.

	Miles	*Cost*	*Average cost per mile*
Previously graded			
Gravel—State money aid....	1.59	$1,318.98	$829.54
Gravel—Convict labor......	.38	798.32	2,100.84
Shell—State money aid..........	2.91	5,211.51	1,790.90
Soil—State money aid...........	114.17	162,217.17	1,420.84
Soil—Convict labor.............	120.92	152,728.09	1,263.05
Sand-clay—State money aid.....	161.69	94,261.07	582.97
Graded—State money aid.......	66.95	124,249.51	1,855.85
Graded—Convict labor..........	32.00	59,228.62	1,850.89
Surface-treatment of old Macadam roads—Money aid.....	14.77	13,592.37	920.27
	705.82	$1,488,682.47	

Road Funds

The State, during the last year, appropriated for road construction purposes $599,648.00. This, together with county and district funds, has given a total of $1,585,550 for the construction of 700 miles of road, and $157,358 for the construction of bridges. In addition to this, we have expended $23,564.00 for maintenance. The State's appropriation for 1917 will be $190,000 State money aid; $240,000, including fees, for the maintenance of the convict force. It is estimated that the automobile licenses, fees, etc., will amount to approximately $400,000, this to go for maintenance purposes, making a total contributed by the State for construction and maintenance purposes of $830,000.

[Approved by G. P. Coleman, State Highway Commissioner.]

WASHINGTON

State Aid Legislation

The public highway fund is derived from a tax of one mill on all property, and is used for the construction of State roads. A system of primary and secondary State roads has been established by the legislature; primary State roads are built and maintained by the State; secondary State roads are built by the State and maintained by the counties. The legislature makes appropriations from the public highway fund for construction of designated portions of the State roads, and for the maintenance of the State highway department. Seven and one-half per cent of the public highway fund is set aside for maintenance of primary highways. Construction and maintenance of State roads is under the direction of the State highway commissioner, appointed by the governor for a term of four years. He is required to compile statistics relating to public highways throughout the State, give advice to local officials, and make recommendations as to needs of highways, with estimated cost; he is also charged with special investigations and duties by the legislature. The State highway board apportions the amounts appropriated by the legislature for any State road to be expended within the boundaries of the several counties through which the road may pass; awards all construction contracts; and decides matters of general policy in connection with the work of the State highway commissioner.

The permanent highway fund is derived from a tax of 1.5 mills on all property; is paid into the State treasury and credited to each county in the full amount paid by such county. It is expended on contracts for surfaced road construction, under certain statutory restrictions. A road improvement under this law may be initiated by the board of county commissioners on its own motion, when the entire cost of construction, except engineering supervision, is paid from the fund; or may be initiated by a petition signed by the owners of not less than two-thirds of the property fronting on the section of the road to be improved, in which case at least 15 per cent of the cost is assessed to the abutting property. Plans and specifications for such work are prepared by the county engineer, subject to the approval of the State highway commissioner. All payments made for such work have to be approved by the State highway commissioner, who also examines and accepts the completed contracts. The expenses of the county engineer in connection with these improvements are paid from the general county funds; the expenses of the State highway commissioner are paid from his office appropriations. Five per cent of the fund is set aside for the maintenance of roads constructed under the provisions of the act.

The State highway board is authorized to establish State quarries to be operated by convict labor. The material prepared at such quarries is used on State roads, or by any city, town or county after the State road requirements have been met, or may be sold in the open market after State and municipal needs are satisfied, at a price of not less than 10 per cent above the estimated cost of production at place of delivery. Five quarries were established under this act. Legislation is pending to turn them over to the counties where they are situated for operation in the same way.

Local Road Laws

The roads of a county not under the township system are in charge of the board of county commissioners. The board divides the county into districts and appoints a supervisor for each. A county engineer is elected biennially.

Where a county has adopted the township system, the roads are under the commissioners or supervisors of each township.

Local Bond Legislation

There are in Washington three operative statutes passed and effective in the years 1890, 1893 and 1913, respectively. The last two are very similar, and the act of 1913, as therein stated, is intended to confer additional power and authority. Bonds may be issued under the provisions of either of these statutes.

The board of county commissioners of any county may, by the act of 1890, whenever a majority of them shall so decide, submit to an election the question of issuing coupon road and bridge bonds in an amount not to exceed 5 per cent of the taxable property in the county, bearing not to exceed 6 per cent interest per annum, and payable at such time as may be fixed by the board of county commissioners. This proposition may be submitted at a general election and a majority of three-fifths of the votes cast is necessary to authorize the issue of these bonds. If bonds are issued, the county commissioners must ascertain and levy annually a sufficient tax to pay the interest on them when they become due and to create a sinking fund to redeem them at maturity.

The county commissioners are authorized by the act of 1893 to establish and construct a system of improved roads on petition setting forth that the public welfare requires that such improvements should be begun without delay and that the county has not sufficient funds. If the commission shall approve the petition, they may by resolution direct that an election be called on the question of issuing bonds of the county to provide funds. If three-fifths of those voting are favorable, the commissioners shall issue the bonds and negotiate their sale at not less than par value. These bonds shall be made payable to the bearer within not more than twenty years from their date and shall bear not exceeding 6 per cent interest. Bonds shall not be issued under the provisions of this chapter in such an amount as will make the aggregate indebtedness of the county exceed 1½ per cent of the value of taxable property therein. When bonds are issued, the board of county commissioners is authorized and required annually to levy and collect a tax sufficient to pay the interest on them, and, in case they are to run longer than ten years, they shall annually levy and collect, beginning with the annual tax levy succeeding the expiration of ten years from the date of the bonds, an additional tax to provide a sinking fund for the payment of the principal thereof. This annual sinking fund levy shall be at least equal to 10 per cent of the amount of the bonds issued.

An act passed in 1913 authorizes the board of county commissioners of any county to submit to the voters of the county the question of issuing negotiable coupon road bonds in an amount not to exceed 5 per cent of the taxable property of such county. This question may be submitted at the general election or at a special election called for that purpose. A three-fifths majority of the votes cast shall be necessary to authorize the issuance of the bonds. If issued, they shall run not to exceed twenty years and bear not to exceed 6 per cent interest. The provisions of this act shall apply not only to roads which are or shall be under the general control of the county, but also to all parts of the State roads in the county and to all roads which are situated or are to be constructed wholly or in part within the limits of any incorporated city or town therein; provided that the board of county commissioners finds that they form or will become a part of the public highway system of the county; provided further that no proposition for bonds shall be submitted which proposes that more than 40 per cent of the proceeds thereof shall be expended within any city or town or within any number of cities and towns. After the bonds are issued, the county commissioners shall levy an annual tax sufficient to pay the interest and at least five years prior to the maturity of the bonds, and thence forward each year until their maturity the county commissioners must ascertain and levy a tax sufficient to accumulate during the last series of years a fund equal to the principal of all the bonds then remaining outstanding and unpaid. The proceeds of this tax shall go into a sinking fund for the discharge of the bonds.

Convict Labor Law

Whenever there are persons confined in the State penitentiary who are physically able to perform manual labor upon the public highways and who shall not be engaged in other work required by the State board of control, the same may be employed upon the construction and improvement of the public highways within the State.

The board of control shall monthly certify to the State highway commissioner the number of persons in the institution named who may be used for the work authorized under this act, and the state highway commissioner shall, whenever possible use such persons in the building or repair of public roads.

All work shall be under direction and supervision of the State highway commissioner, but the control and management of the convicts shall be under the supervision of the State board of control. All expense of care, maintenance and transportation above 25 cents per day for each convict shall be paid from the funds authorized to be used on the road being improved. Twenty-five cents per day shall be paid from the fund appropriated for the maintenance of the penitentiary.

County commissioners may order jail prisoners to work on the public roads under direction of the sheriff at a distance of not to exceed 5 miles from place of detention.

While the law for prison labor remains unchanged, the number of convicts available for road work has decreased since the prohibition law went into force, to such an extent, that there is no likelihood of any road work by prison labor during the ensuing two years.

Automobile Registration

Application for a motor vehicle license is made to the county auditor, and is forwarded to the secretary of State, who issues a license and number plates.

The annual license fees are based on horse power and capacity, as follows:

All motor cycles, $2.50.

Automobiles, 25 h.p. or under, $3; 25 to 40 h.p., $5; 40 h.p. and over, $7.50; public, per horse power, 50 cents.

Motor trucks, under 2 tons capacity, $10; 2 tons and under 3, $15; 3 tons and under 4, $20; 4 tons and not over 5, $25.

Motor trucks for hire, under 2 tons capacity, $20; 2 tons and under 3, $30; 3 tons and under 4, $40; 4 tons and not over 5, $50.

Auto stages pay at the rate of 50 cents per horse-power and in addition $1 per passenger capacity of the vehicle.

Demonstration motor cycles, $3; all other demonstration motor vehicles, regardless of horse-power or capacity, $5. Proposals to increase these rates slightly, especially on motor trucks and for hire vehicles, are now pending before the legislature.

The costs of administration of the law are paid from the receipts of fees. The balance of the fees is paid into the permanent highways maintenance fund. Fines are paid into the same fund. Proposals to divide these fees and fines, one-third to State roads, one-third to county highways, one-third to cities are now pending before the legislature.

Highway Officials

State Highway Board, Olympia.—Governor Ernest Lister, chairman; James Allen, State highway commissioner, secretary; W. W. Sherman, State treasurer; C. W. Clausen, State auditor, and E. F. Blaine, chairman of the public service commission.

Road Funds

The 1915 legislature appropriated $2,152,288 for State roads for the two years ending March 31, 1917, and reappropriated $153,640 for that purpose; it also appropriated $4,000,000 for permanent highways. It was estimated that $4,000,000 of county funds would also be spent during the two years. The legislature now in session is expected to make about the same appropriations.

[Approved by JAMES ALLEN, State Highway Commissioner.]

WEST VIRGINIA

State Aid Legislation

At the 1913 session of the legislature a law was enacted establishing a State road bureau consisting of the professor in charge of the railway and highway department of the State university to be chief road engineer and chairman of the bureau; the director of the State experiment station and two additional members to be appointed by the governor. Both of these two members shall not be appointed from the same political party. The professor in charge of the railway and highway department at the State university is to be appointed by the governor. The bureau is to give instruction and advice in road building, collect data, test materials, and have such supervision of the roads of the State as is consistent with the constitutional provision on this subject and to see that all road laws are enforced.

The State grants aid to the counties in the form of convict labor to be employed under the supervision and in accordance with the plans and specifications of the State road bureau.

The road bureau is stationed at the University and a highway laboratory has been established preparatory to testing road materials.

A special course in highway engineering has been provided. The law requires all county road engineers to attend this course for at least 10 days in each year. About 155 attend.

Road Bond Legislation

The county court of any county may improve the main roads thereof, and may pay for them by the issuance of the bonds of the county. The court, upon petition of 50 voters of a district or 100 voters of a county shall submit the proposition at a general or special election, and a three-fifths favorable vote of all votes cast shall be necessary to authorize the issuance of the bonds. The amount of bonded indebtedness that may be outstanding at any one time shall not exceed 5 per cent of the value of the taxable property within the county. Interest on these bonds shall not exceed 6 per cent, and the bonds shall be sold at not less than par; the term not to exceed thirty-four years, and an annual tax shall be levied on all property subject to taxation in the county sufficient to meet the interest and to create a sinking fund for the redemption of the bonds at maturity.

In like manner the county court may issue road bonds of any magisterial district within the county. Serial bonds are now being issued; to January 1, 1917, $13,281,500 had been voted, of which $7,678,500 was in 1916.

Local Road Legislation

Three county commissioners, elected for six years, one every two years in November at regular elections, have control of roads. The county commissioners may appoint a county engineer to serve one year.

Convict Labor Laws

Circuit, criminal and justice courts shall sentence convicts to work on roads and bridges under the county court, its agents or engineer. County courts may apply to the State board of control for State prisoners to work upon the State highways of the county. The application will be granted if prisoners are available, provided the State board of control may for good cause refuse to grant any application. A total of 72,531 days' work was done by convicts on roads in 1915, and about the same in 1916.

Road Funds

There are no State funds for road work; the appropriation for the State road bureau is $10,300.

The levies for road and bridge purposes for 1915–16 were $1,900,000 and county bonds to the amount of $5,413,000 were voted. In 1916–17 the levies were $1,900,000 and the bond issues $7,681,500.

Automobile Registration

The law provides for annual registration with the State auditor. The fee for motor vehicle registration is $10. Chauffeur's license (perpetual) $2. The registration revenue is not applied to roads but goes into the general fund of the State.

Highway Officials

State Road Bureau.—A. D. Williams, chairman and chief road engineer, Morgantown; the director of the State experiment station ex-officio and two members appointed by the governor. Personnel John Lee Coulter, Morgantown; A. H. Gray, Cameron; J. W. Lynch, Union.

[Approved by A. D. WILLIAMS, Chief Road Engineer.]

WISCONSIN

State Aid Legislation

The State highway commission consists of five members, who are non-paid except actual expenses. Three members are appointed by the governor. The dean of the College of Engineering at the University of Wisconsin and the State geologist are members ex-officio. The State highway engineer is appointed by the State engineer with the approval of the State highway commission.

The boards of county supervisors are required to select a continuous system of roads known as the county system of prospective State highways. These roads may be constructed by the town, county and State jointly, or by the county and State jointly. In the former case, the town, county and State each assume one-third of the cost; in the latter case, the county assumes three-fifths of the cost and the State two-fifths. This applies to both road and bridge construction.

Improvements on this road system are made by a county highway commissioner, elected by the county board, under the general directions and in accordance with the plans and specifications of the State highway commission. A State county road and bridge committee, elected by the county board or appointed by its chairman, is empowered to purchase and sell county road machinery, to enter into road and bridge contracts in the name of the county, to generally direct the expenditures of all road funds, and to see that all arrangements for the construction and maintenance of highways and bridges provided by the county board are properly carried out.

After improvement, State roads and bridges are maintained by the counties.

Local Road Legislation

The county board of each county elects a county highway commissioner. Upon the first election, he serves one year; upon the second and succeeding elections, two years. The county highway commissioner is in charge of all construction and maintenance work, except that the county committee acts as a board of directors jointly with the State highway commission in the general control and conduct of the work in each county.

General jurisdiction over all roads other than those on the State system in each town is in the hands of town boards, consisting of three members elected annually. The method of paying the road taxes is determined by statute. The poll tax is included in the tax roll and levied against all males within the legal age limits. The cash system of payment of road taxes prevails in most counties.

Local Bond Legislation

Any county, through its board, may issue nontaxable coupon bonds bearing interest at 5 per cent, payable semiannually, for the original improvement of any portion of the system of prospective State highways. The bonds may run not to exceed ten years, and the entire issue, when added to other county indebtedness, must not exceed 5 per cent of taxable property, as ascertained by last assessment. The bonds may not be sold below par or outside of the county until the residents of the county have had a reasonable opportunity to purchase them, and when sold, the proceeds must be apportioned by the county board. The form of the bonds is to be approved by the State highway commission, and the bonds are to be printed from plates furnished by the commission.

The bonds are to be divided as to denominations and due dates so as to have an equal amount payable each year. The interest and principal are provided for by a direct tax to be assessed by the county board. Provision is also made for the issuance of bonds conditioned upon the payment of all interest by private subscriptions, but money or approved securities must be first deposited to secure the payment of this interest. State aid may be obtained upon proceeds from bond sales not to exceed one-half of the tax levy in the county for the payment of the face of the bonds.

No bond issue shall be authorized for more than one-fifth of 1 per cent of the assessed value of all the taxable property in the county until the proposition has been submitted to a vote of electors of the county, and a majority of those voting have been favorable. A petition signed by qualified electors equal to 10 per cent of the number of votes cast for governor at the last general election may secure the submission to a vote of any proposition to issue bonds.

Any town may issue bonds for the original improvement of any portion of the system of prospective State highways in a manner similar to that of the county, except that the proposition must, without exception, be submitted to a vote of the qualified electors of the town at a regular town meeting, or at a special meeting called for the purpose. The rate of interest and other terms of the bonds are practically identical with those of the county.

Convict Labor

The law provides that convicts in county jails may be used in quarrying stone for road work. The law also provides that convicts in the State prison may be used in the construction of roads. The employment of convicts on State roads is optional with the counties. A number of the counties may use convicts for their work in 1916.

Automobile Registration

The law provides for annual registration with the secretary of State. The schedule of fees is as follows: Motor cycle, $2; all other motor vehicles, $5; dealers and manufacturers, for each garage, $10.

Three-fourths of the net registration revenue is returned to the county from which collected at the end of each year, to be expended in repairing highways outside of incorporated towns and cities. The remaining amount is credited to the State highway fund in the State treasury.

Highway Officials

Wisconsin Highway Commission, Madison.—J. A. Hazelwood, chairman, Jefferson; W. O. Hotchkiss, State geologist, Madison (ex-officio); F. E. Turneaure, Madison (ex-officio); John S. Owen, Eau Claire; J. H. Van Doren, Birnamwood.

A. R. Hirst, State highway engineer; M. W. Torkelson, bridge engineer; Hal S. Rockwood, chief clerk.

Road Funds

The State-aid law was passed by the legislature in 1911, and at that time an annual appropriation of $350,000 was made.

For 1916, the amounts available from the towns, counties, and State amounted to about $3,600,000 in round numbers.

The appropriation for the support of the commission in 1916–17 is $65,000. The counties now pay the actual cost of surveys made by the commission for them, which was formerly a charge against the appropriation for the commission.

Progress Report

There are 75,887 miles of road in Wisconsin, which has 2,500,000 population, nearly 2,000,000 living in rural districts. A 9-foot road has proved most economical for local conditions. The miles of road improvements carried out to the close of 1916 are as follows: Graded roads, including those surfaced, 4,846.19; non-permanent, 212.06; broken stone, 1,179.71; gravel, 974.54; concrete, 207.63; miscellaneous, 198.94.

[Approved by A. R. Hirst, State Highway Engineer.]

WYOMING

State Aid Legislation

Certain highways, 2991 miles, have been designated as public highways to be improved by State convicts, under the control of the State commission of prison labor. All locations and surveys of such highways are to be made under the direction of the State engineer, while the county commissioners are required to secure rights of way and construct bridges in connection with plans made by the State engineer. Appropriations of $17,500 have been made for equipment for convict labor work. About 100 miles of road have been thus improved. No State money aid is granted.

Local Road Laws

The county commissioners have charge of roads. Each county is divided into road districts, and a supervisor is elected for each district, who is under the direction of the county commissioners.

Local Bond Legislation

The State constitution authorizes the county and subdivisions thereof to create indebtedness not to exceed 2 per cent of their taxable valuation, but there has been no statutory enactment, either general or special, under the authority thus conferred, for the issuance of road bonds.

Convict Labor Laws

Any convict may be put to work on roads and streets.

Automobile Registration

The law provides for annual registration of automobiles with the secretary of State. The registration fee is $5.

Four dollars of each registration fee paid is returned to the county treasurer of the county from which received, and shall be credited to a special fund for expenditure only for temporary improvement of the county roads. The remaining one dollar of such registration fee is retained by the secretary of State for the payment of expenses incident to such registration. (Chapter No. 95, Laws 1913.)

Progress Report

There are about 15,000 miles of county roads in the State and several thousand miles of roads to which the counties pay no attention. Over 1000 miles of road in hilly and mountainous sections have been graded and drained.

Road Funds

In addition to four-fifths of the automobile license fees, various sums are received from inheritance taxes, road poll taxes, proceeds of the U. S. Forest Reserve fund and general county taxes. From 30 to 35 per cent of the total tax proceeds is spent on roads, including bridges. It is estimated that about $500,000 will be available for road work in 1917.

[Approved by JAMES B. TRUE, State Engineer.]

HIGHWAY IMPROVEMENT IN CANADA[1]

In the Dominion of Canada there are about 250,000 miles of graded roads. Road-building is a slow process, and in most countries it has taken half a century at least to provide adequate surface construction. The immediate objective in Canada should be to substantially improve about 16 per cent of the total, or 40,000 miles, which would carry the more concentrated market or farm traffic; while about 2 per cent additional, or 5,000 miles should be treated on a trunk road basis. The total cost might be approximately estimated at $250,000,000, of which about $50,000,000 has been spent.

The following brief outlines of road administration in the various provinces of the Dominion, contain only sufficient of the essential facts in each case to indicate the general situation.

From these it will be observed that no two provinces have the same organization. The same is true of the various American states, and of all countries in the world. This great variety of organization is due to the variety of local circumstances, which have influenced the general trend of public feeling, action and administration on which road organization is based. Thus the mountainous character of British Columbia has prevented uniform municipal organization such as is possible in the prairie provinces. The French code and French characteristics of Quebec have made a striking difference as compared with Ontario; in the former, a more paternal system is acceptable, while in the latter case, local self-government is more congenial to the spirit of the people.

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[1] By Hon. W. A. McLean, Deputy Minister of Highways of Ontario, Toronto, Ont., with the coöperation of J. E. Griffith, Deputy Minister and Public Works Engineer of British Columbia; L. B. McMillan, Secretary of the Department of Public Works of Prince Edward Island; J. D. Robertson, Provincial Engineer of Highways of Alberta; Hiram Donkin, Road Commissioner of Nova Scotia; H. M. Blair, Secretary of the Department of Public Works of New Brunswick; Archibald McGillvray, Commissioner of Highways of Manitoba; H. S. Carpenter, Provincial Superintendent of Highways of Saskatchewan.

British Columbia

Roads, 15,945 miles; trails, 7,754 miles.

Road-building in British Columbia has been almost entirely a provincial work, due largely to the mountainous and heavily timbered character of the country.

Under the department of public works, the general system has been to have a competent engineer as deputy minister, and under him, experienced road superintendents for each of the 29 electoral districts. The superintendents employ foremen and laborers; and details in each district are largely left to the judgment of the road superintendent.

Provincial estimates for roads and bridges in 1901 amounted to $344,000; in 1915 estimates amounted to $2,459,000. A special program was provided about 1910, with an estimated outlay of about $20,000,000, the greater part of which has been spent in the construction of main roads. The total expenditures on roads, trails, bridges and everything pertaining to highways for the ten years ending December 1, 1916, was $30,320,585.

Climatic conditions in British Columbia in some respects resemble the ordinary conditions of Canada, but on the Coast, there are roads which can be used the year around, which have no rest by snow protection, and which suffer in the winter by heavy rains.

Alberta

Little attempt is made in the Province to construct surfaced roads, owing to the absence of suitable road-making material. The roads are, therefore, merely earth-graded roads, with not always continuity of grading. It is possible and customary on these prairie roads to pass over those portions where the soil in its natural state will carry traffic, and to first make passable those portions on which grading, drainage or other improvement is most urgent.

Expenditure is made on roads by the rural municipalities and local improvement districts; also by the provincial department of public works, under the engineer of highways.

Municipal expenditure in 1913 was $681,000; in 1914, $865,190; in 1915, about $900,000; and in 1916 about $1,000,000.

Provincial expenditure is devoted largely to trunk road improvement, while the municipalities seek to improve the outlying branches.

In 1916 the provincial government spent $357,475 on trunk roads and bridges, $182,460 on the construction and maintenance of side roads not included in the trunk road system; $150,012 on the construction and maintenance of bridges not on the trunk road system, and $68,314 on the 69 ferry services in the Province; a total of $758,261.

The province recognizes in general two classes of trunk roads: First, those paralleling railway lines which are dealt with by the Province, both as regards construction and maintenance; and second, those leading out from shipping or business centers, at right angles to railway lines, and toward which an endeavor is made to obtain the co-operation of rural municipalities and local improvement districts. Local organizations, however, use their funds chiefly on roads leading traffic to the provincial trunk road system.

Saskatchewan

Road improvement is largely carried on by the Province under a board of highway commissioners, but with increasing settlement, rural municipalities and local improvement districts have been formed. Whereas roads were formerly maintained entirely by the provincial government, municipal organization is steadily adding its force to the betterment of roads.

The duties of the provincial commission are as follows:

1. To lay out, plan and determine upon a system of public highways for the province, which may from time to time be altered or modified as the board may determine.
2. To determine upon the most feasible and economical methods for constructing, improving and maintaining public highways.
3. To furnish the officers of the municipalities with information respecting the construction, improvement and maintenance of public highways.
4. To appoint such engineers, inspectors and officers as are necessary for the proper carrying out of the duties of the board and the provisions of the act.

The board endeavors to devote the most of its expenditure to main roads, but also assists or constructs minor roads and bridges not on main roads, which, for special reasons, are beyond the ability of the local municipality to build. The board also assists local municipalities to the extent of 50 per cent of the cost of improvements, when these improvements have been carried out in accordance with the regulations of the board.

The use of the road drag is encouraged with good results; ferries are operated; while all bridges of over 20 feet span are built by the commission. In 1916, about 2300 miles of road were kept in repair by use of the drag.

For 1915, the provincial appropriations were as follows: Roads and bridges (from revenue), $500,000; steel bridges on concrete foundations (bond issue), $300,000; highway construction (bond issue), $1,200,000; total, $2,000,000.

Owing to conditions created by the war, it was deemed advisable to cut down expenditures on road and bridge work very materially, so that, while during 1912, 1913 and 1914, the board spent each year upwards of $2,000,000 for this work, during 1915 it spent only about $800,000 and during 1916 only about $450,000, divided as follows: Roads and bridges, $150,000, from revenue; steel bridges on concrete foundations, $100,000, from bond issue; highway construction, $200,000, from bond issue.

As with Alberta, metalled roads do not exist outside the cities and towns. At the present stage of development, little can be attempted other than to attend to the worst places, so that, though the Province may undertake in any year to complete a certain mileage of roads, the actual work consists in grading such parts of the road as are impassable, because crossed by coulees, sloughs, or other obstacles. Thus in a given stretch of prairie road, possibly only 10 per cent of the distance actually receives attention.

Manitoba

Road mileage, 68,000.

The provincial government maintains a road department under a provincial highway commissioner, while municipal organization is active. The Province is divided into 108 rural municipalities with population varying from 600 to 5000 in each. The municipal council (controlling local expenditure) consists of a reeve and four or six councillors, half of whom are elected for one year, and the remainder for two years. Municipal organization is very similar to that of Ontario. Local expenditures, including those for road construction and maintenance, are altogether under municipal control.

In respect to road construction, municipalities are assisted by the provincial government by direct grant in a few cases and by operation of the good roads act, administered by a good roads board of which the provincial highway commissioner is chairman. Expenditures under the good roads act are made under the direction of engineers of the provincial department and in conformity with well-defined road systems, approved by the board, within the municipalities operating under the act.

The general features of the good roads act are as follows:

1. The municipal council must initiate the scheme of improvement.
2. The municipal council must, by resolution, submit the scheme of improvement to the good roads board for its approval.
3. The scheme is then examined and reported upon to the board by an engineer of the department.
4. If the board approves of the scheme, such approval and decision is then reported through the minister of public works to the lieutenant-governor-in-council, for his approval.
5. The approval of the lieutenant-governor-in-council having been obtained, the secretary-treasurer of the municipality is notified and the municipal council may then proceed with the scheme.
6. When the improvement has been carried out to the satisfaction of the department engineer, the municipality will then receive the assistance prescribed in the act, namely: for earth roads, one-third of the cost; for gravel roads or any form of road more permanent than earth, one-half of the cost; for timber structures, one-third of the cost and for permanent structures one-half.
7. A vote of the taxpayers adopting any proposed scheme of road improvement is required only in such cases where the cost of such improvement is to be defrayed from a sale of a debenture issue for that purpose.

The good roads act also provides for assistance towards the cost of structures on roads not under the act, to the amount of one-third of the cost of timber structures costing $500 or more and one-half the cost of permanent structures costing $200 or more.

The expenditure in the Province in 1916 was as follows: Municipal expenditure alone, about, $900,000; under good roads act, $350,640; total, $1,250,640.

The former expenditure has been made solely under the direction of the municipal councils. It would be difficult to approximate the real value of this work or to give an idea of what it stood for in constructed road mileage. In very few instances is there a well-defined policy or system being followed. The work performed is more in the way of repairs, constructing small structures, and relieving the more emergent and pressing needs.

Towards the expenditure of $350,640 incurred during 1916 under the good roads act, the provincial government contributed $147,823. This work is carefully carried out under the supervision of the engineers of the board, along approved methods of modern road construction. The services of the engineers are given to the municipalities free of any charge.

Ontario

Road mileage, 55,000.

The Province of Ontario has a department of public highways in charge of a deputy minister, chief engineer and staff, with a considerable range of duties, both educational and constructional. The collection of motor vehicle licenses is a branch of the highways department, from which a revenue of $640,000 was received for 1916.

Of the total road mileage (55,000 miles) about 20,000 miles are merely well-graded earth roads; about 22,000 miles have been more or less satisfactorily surfaced with gravel or stone; while the remainder, 13,000 miles, are little used and unimproved.

Southern Ontario is the most densely occupied portion of Canada where, in an area of about 40,000 square miles, there is a population of about 2,500,000, one-half of which is urban and the other half rural. In the southern and populous portion, which is chiefly agricultural, there is an annual municipal expenditure on roads in the open country of about 1,000,000 days statute labor and $2,000,000 in cash, annually; while the Province spends about $1,500,000 annually through three channels viz.:

1. Subsidies to leading market and main roads in southern Ontario.
2. A special appropriation of $5,000,000 on trunk colonization roads in northern Ontario.
3. Minor colonization roads in northern Ontario.

Owing to the strong claims of agricultural communities, the assistance given by the provincial government to the better class of construction in southern Ontario has been largely confined to subsidizing the leading market roads in each county.

Ontario has both township and county organization. Township councils are elected annually, and the reeve of each township (town and village) is, ex-officio, a member of the county council. Township councils, primarily, have control of all the roads, but a county council is authorized to take over from the townships the leading roads of the county for construction and maintenance. To this system of county roads, the provincial government contributes 40 per cent of the cost of construction, and 20 per cent of the cost of maintenance. Two-thirds of the counties are operating under this plan with good results, and to the present time, a total of over $6,750,000 has been spent on the work. It is anticipated that the remainder of the Province will adopt county systems in a very short time.

Under new legislation for main roads, more attention will be given to the development of certain trunk lines, for which there is a growing demand.

A main road is interpreted as one running directly between two important terminal points or cities, and passing through a series of municipalities. Such series of municipalities may petition the highways department for construction as a main road; and if the petition is endorsed by three-quarters of the municipalities affected, the department will make surveys, prepare specifications and appoint a special board of commissioners to take charge of the construction and maintenance of the road. The cost in the engineer's report is apportioned among the municipalities benefited (the government contributing 40 per cent); and the commissioners then act as a court of revision to hear the appeal of any parties affected as to the engineer's apportionment of the cost. The commission may confirm or revise the engineer's report, and unless a majority of the municipalities then petition against the work, the commission is authorized to proceed with construction.

At the present session of the Legislature a bill will be considered providing for the construction and maintenance of a system of highways, under the direct control of the provincial department, the Province to contribute 70 per cent of the cost and the remainder to be levied on the local municipalities. For roads immediately adjacent to cities of over 10,000 population, the city will be required to contribute 30 per cent of the cost; such suburban roads thus being paid for in the ratio of 30 per cent by the city, 30 per cent by the township and 40 per cent by the province.

It will thus be seen that, in the Province of Ontario, a threefold classification, very desirable in road organization, is being evolved in the following manner:

1. Main or trunk roads to be constructed and maintained by the provincial department of public highways, or in some cases by special commissioners under the guidance of the provincial highway department; the cost of the latter to be met by provincial subsidy and direct assessment on cities and rural municipalities benefited.
2. Leading market roads, to be under the control of county councils, subject to regulations and inspection of the provincial authorities; the cost to be met by provincial subsidy and county levy on all assessible property within the county, including cities.
3. Local feeders, to be under the control of township councils, and at the expense of the township.

New Brunswick

Road mileage, 14,000.

The department of public works consists of two divisions, roads and bridges. The minister of public works is the head of the department and the provincial road engineer is the road authority.

There are 15 counties in the province, and in each county there is appointed a road inspector. The counties are subdivided into 146 parishes, and each parish assesses for road purposes at the rate set down in the road laws. The highway act of 1913 and an amendment in 1915 are in force. The taxes may be paid in cash or worked out in statute labor. When necessary the parishes are again divided into road divisions, and a road supervisor placed in charge of the roads in each division. A division is never larger than the parish. The administration is a strictly government one.

The government subsidizes each road division annually, but there is no established rate of subsidy. Generally the poorest divisions are allotted the most. The government expenditure in 1916 was about $215,000. All the expenditures are made by the road supervisors, who submit sworn statements to the government, and individual checks are issued for government expenditures and orders on the county treasurers for municipal expenditures.

Nova Scotia

Road mileage, 18,000.

The rural part of the Province has county organizations, 18 in all. In 1880 the municipalities had full control of the roads and bridges but neglected them, and the provincial government enacted various laws; first taking over the construction of the larger bridges; then the maintenance of larger bridges; then the construction and repair of smaller bridges; and finally the maintenance of highways to a great extent.

In 1908, a provincial commissioner of highways was appointed, an office under the commissioner of public works.

Expenditure under the provincial highway commission in 1916 was approximately as follows: For highway structures of permanent material out of capital (not included with larger bridges), $147,902; for construction and maintenance of highways including smaller bridges, out of capital, $54,305; for construction of larger bridges out of capital, $113,565; total, out of capital, $315,772. For construction and maintenance of highways, including smaller structures and repairs to larger bridges, out of revenue, $216,723. Total expenditure, $532,495.

The total amount of revenue for the last fiscal year from automobile licenses was $32,870, and is set apart specifically for road purposes. An amount of about $250,000 is assessed annually by the municipalities under the Statute Labor Law, and the expenditure is under the control of the county authorities.

In carrying on the work of the provincial department, counties are separated into districts for provincial highway expenditure, and over each district is placed a provincial inspector, there being 39 inspectors in all. It is the duty of each inspector to send to the provincial highway commissioner, yearly, a report of road improvement required, with an estimate of the cost. When such report and estimate have been approved by the provincial department, it is the duty of the inspector to organize and carry on the work and to return pay rolls to the provincial department.

The Province up to the present has very little but earth roads.

Prince Edward Island

Road mileage, 3,800.

The Province is not divided into municipalities, and all the roads are maintained directly by the provincial department of public works.

Each school district is constituted a road district, of which there are 470 in the province, clear of the incorporated towns, with an average of about 8 miles of road in each. Each road district is presided over by a road master who collects and expends the road tax in his district and has charge of all work in it. A road machine and operator are placed at the service of each eight road masters.

The soil of the province is a sandy loam and about 90 per cent of the roads are earth roads maintained by road machinery. The right-of-way is in general 40 feet wide and the roadbed 18 feet.

The total amount expended on roads in this Province is about $50,000 per annum, equal to about $13 per mile.

Quebec[1]

In the Province of Quebec, local municipalities, according to the municipal code, look after the making and maintenance of roads. This does not mean that all the roads of the municipalities are built and maintained directly by the local council. Practically, it is the contrary that exists.

Maintenance of Earth Roads.—Excepting certain municipalities in the eastern townships, roads in local municipalities are maintained by each land owner, and are subject only to a general supervision by the council (in certain exceptional cases, the county councils build or maintain certain roads).

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[1] Contributed by Hon. B. Michaud, Deputy Minister of Highways of the province of Quebec, Montreal, P. Q.

The government of the Province of Quebec, though anxious to improve the system of road maintenance, has respected the autonomy of local municipalities and has taken no coercive action thereon, but, in order to induce the local municipalities to give up the system of maintenance by the land owner, it has, in 1908, decided to grant an annual subsidy to local municipalities taking at their own charge the maintenance of their roads. Up to December, 1916, out of the 1100 municipalities of the Province, 498 had taken the government's offer.

The subsidy is equal to the expenditure incurred in one year for the maintenance of summer roads, the maximum of each subsidy varying from $100 to $400, according as it may be paid either to a village, parish, or township municipality, or to any of them, merely for the maintenance of by-roads or for the maintenance of all the roads within their limits. All the expenditure is controlled and the accounts audited by the department of roads, which also inspects the roads under maintenance in order to ascertain that the municipalities derive the greatest profit possible from the subsidies granted.

The department of roads, since three years, has added new conditions to those already set forth in the act, namely:

(a) The obligation for the municipality to have a road grader and split-log drags.

(b) The obligation for the municipality to spend each year, out of its appropriation for earth roads, a certain amount towards permanent work, such as digging ditches, removing boulders, reshaping the road, cutting knolls, etc.

Surfaced Roads.—As far back as 1908, the government has granted subsidies equal to $1000 a year for macadam and $500 a year for gravel, in the proportion of 50 or 40 per cent of the amount expended by each municipality. Besides, one-half of the amount expended for the operation of the machinery was refunded.

However, the scope of the act has been extended and in several instances subsidies exceeding $1000 are granted. As a matter of fact, 50 or 40 per cent of the whole amount expended for the macadamizing or graveling of a given stretch of road is granted.

Loans for Municipal and Provincial Roads.—In 1912, without giving up the system of the 50 per cent grant, the government secured authorization from the legislature to borrow $10,000,000 and to give to the local municipalities allocations sufficient to cover the whole cost of the work done by them in gravel or in macadam. In 1915, the amount was increased to $15,000,000. Out of this $15,000,000, the government has carried out two plans: First, it has allocated, as already said, certain sums to local municipalities for macadamizing or gravelling. Second, it has employed a certain part of the $15,000,000 for the building of trunk roads between important centers of the province. The other part of the $15,000,000 has been allocated to the municipalities in the following manner: The government borrows the money, then it hands over to the municipalities such amounts as required, according to estimates drawn up by the department of roads. The only obligation assumed by the municipality is to pay to the government an annual interest of 2 per cent, during 41 years, on the amount allotted, the balance of the interest and the sinking fund being paid by the government. During the last session, the $15,000,000 have been increased to $20,000,000, but the interest to be paid by municipalities on the money granted out of the $5,000,000, will be 3 per cent. Of course, all work and expenditure is controlled by the department of roads.

Progress.—Since 1912, the government has built five provincial roads, namely: the Montreal-Quebec road, the Montreal-Rouse's Point road, the Chambly road, from Victoria Bridge, Chambly, and then to St. Johns, P. Q.; the Sherbrooke-Derby line road, and the Levis-Jackman road, covering over 300 miles in all.

Since 1911, there has been built in the province, under the control of the department of roads, 1279 miles of macadam, and 568 miles of gravel roads, in all 1847 miles of improved roads. In these figures, are included the 300 miles of trunk roads above referred to.

The department of roads owns 57 complete outfits for the construction of macadam. These outfits are lent or rented to the municipalities. Besides, it owns a certain number of tractors, portable engines, etc., which are employed by the department of roads for direct construction. Aside from the government's outfits, about 150 outfits are owned by municipalities. They have been paid with the money allotted by the government to those municipalities out of the $10,000,000 referred to above.

The department of roads has a well equipped laboratory for the testing of road materials.

Maintenance of Surfaced Roads.—A special act has been passed during the last session (1916) providing for the maintenance of provincial roads directly by the government with the financial aid of the interested municipalities, and for the maintenance of macadam or gravelled roads built by the municipalities, with the aid of the government. In the latter case, the minister of roads has the right, in case of neglect from a municipality, to order the repair or maintenance work to be done under his supervision, at the expense of the municipality. The money required for the carrying out of this act will be taken out of the ordinary annual appropriation, which, at the last session, has been, for that purpose, raised from $250,000 to $300,000.

ROAD SYSTEMS OF FOREIGN COUNTRIES

Austria-Hungary

The roads in Austria-Hungary are divided into four administrative classes, namely; government roads, provincial roads (designated county roads in Hungary), district roads, and town roads (designated parish roads in Hungary). The government roads, of which there are 10,008 miles in Austria and 5600 in Hungary, are constructed and maintained at the expense of the imperial government, which has complete supervision over construction and maintenance. The provincial roads in Austria, of which there are 2288 miles, and county roads in Hungary, of which there are 17,400 miles, are constructed and maintained at the expense of the province or county, the imperial government contributing in some cases. The district roads, of which there are 39,212 miles in Austria and 8100 miles in Hungary, are constructed and maintained by the districts, except that very poor districts are aided by the province or the county. The town roads, of which there are 22,756 miles in Austria, and the parish roads, of which there are 700 miles in Hungary, are local roads and are paid for by the town or parish, the province or county occasionally aiding by grants. The total mileage of all roads in Austria was 74,265 miles in 1909, and in Hungary 31,800 miles in 1910. The average cost of maintenance in Austria is given at about $311 per mile per annum, and in Hungary $282, exclusive of bridges. In both Austria and Hungary the general government has general supervision over all roads. In Austria the road administration is under the ministry of the interior, under which there are district engineers, each in charge of 74½ miles of road. Under each of the district engineers are three road masters,each having about 24.9 miles of road, and these in turn supervise the actual road workers or patrolmen, each of whom has about 2.9 miles of road to maintain. There are in all about 4000 men employed on the Austrian government roads. The Hungarian road system is similar and employs about 2500 men.

Denmark

The roads of Denmark are divided into main roads, of which there were 4213 miles in 1910, and local roads, of which there were 22,505 miles in 1910, or a total of 26,718 miles. The main roads are maintained at the expense of the counties, of which there are twenty-one in the kingdom, and the local roads are maintained at the expense of the parishes, which are sub-divisions of the counties. There is a general superintendent of highways who has supervision over all the highways in the kingdom. The direct supervision, however, is by the counties for main roads, and by parishes for local roads. The government does not grant money aid. The principal roads in the kingdom are maintained by a patrol system, under which each patrolman has charge of about 2½ miles of road. The cost of construction varies widely, ranging from about $1300 to about $8700 per mile, the character of construction being usually either gravel or macadam.

Great Britain and Ireland[1]

England and Wales.—The total mileage of roads and streets in 1913–14 was 152,085. Of this total, 33,624 miles were in urban areas, and the total expenditure on maintenance and improvements, other than out of loans but including loan charges, was £10,983,762, an average of £152 per mile. The mileage in rural areas was 118,461 and the expenditure thereon £5,718,407. In the rural areas, 23,833 miles were classified as main roads, and the expenditure on these roads per mile was £122. The mileage of roads other than main roads in rural areas was 94,628 and the expenditure per mile averaged £26. The roads and streets in England and Wales are maintained by 1,891 local authorities. The 78 large towns (county boroughs) maintain 10,304 miles. The 30 London authorities maintain 2,216 miles, and the remaining mileage is maintained by 62 county councils, 248 non-county boroughs (the smaller towns), 812 urban districts and 661 rural districts. The mileage of main roads maintained by, or at the cost of, the 62 county councils is 28,199. The cost of maintenance is provided for by rates on property levied by the local authorities, with some assistance from the central government in the form of (a) assigned national revenues and (b) exchequer grants. Loans raised for highway purposes are subject to the sanction of the Local Government Board, which fixes the number of years within which they shall be repaid. As regards improvements, the highway authorities in England and Wales, in common with Scotland and Ireland, also receive some assistance from the road improvement fund administered by the Road Board, for which see below.

Scotland.—In Scotland, the system of administration differs in many points from England and Wales. It is embodied mainly in the road and bridges (Scotland) act, 1878. Outside the 205 burghs, the roads are vested in 33 county councils and are maintained by them through 99 district committees. The total mileage of roads in Scotland is 24,908, of which 22,664 were maintained by the county councils in 1913–14 at a cost of £850,965, and 2,244 by the burgh councils at a cost of £559,541. These figures include expenditure on improvement and loan charges, but not expenditure out of loans. Although, as in England and Wales, the cost of the maintenance of roads is provided by the local authorities out of local rates, with some assistance from the imperial exchequer, the system of assessment differs from that of England and Wales. Burgh authorities in Scotland do not require the assent of any authority to the raising of loans for highway purposes. The county councils require the approval of the standing joint committee, which is a county authority.

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[1] Revised by W. Rees Jeffreys, Secretary, The Road Board, London.

Ireland.—In Ireland, the system of road maintenance differs in some important details both from England and Scotland. Ireland has a very large mileage of road in relation to its area and population, the total mileage being 58,334. Outside the 6 large towns and the 119 smaller towns and urban areas, the roads are maintained by 33 county councils. Although the responsibility for carrying out the work rests with the county council and the county surveyor, the control of the expenditure rests largely with the 213 rural district councils, whose consent to expenditure is practically necessary before money can be spent by the county councils, even on the main roads in the county. In respect of this dual control over expenditure, the Irish system differs both from the English and the Scotch. The total expenditure in Ireland on roads in 1913–14 was £1,178,649. All loans for highway purposes require the sanction of the Local Government Board for Ireland.

The Road Board of the United Kingdom.—The only highway authority common to the three countries is the Road Board, established in 1910, which makes contributions towards approved schemes of improvement. The income of the Road Board for the year ended March 31, 1915, was £1,620,974, but in August, 1916, the revenue of the road improvement fund was retained in the exchequer for the purposes of the war, and the grants since made and promised to local authorities have been of a very limited character, and chiefly for the purposes of preserving important roads by tar treatment from deterioration. These payments have been made out of the accumulated funds of the Board, which on March 31, 1916, amounted to £2,507,665, exclusive of grants promised at that date. Between the outbreak of war and June 30, 1916, works on public roads required for military purposes have been carried out under the supervision of the Road Board to a total of £1,051,131, to which the War Office contributed £774,631, the Admiralty £22,197, and the Ministry of Munitions £28,901, the balance being paid by the Road Board and the highway authorities.

France

The roads of France aggregate 519,148 miles and are divided into the following classes: national roads 23,756 miles; department roads 8,161 miles; vicinal roads, sub-divided into roads of through travel 107,049 miles, and roads of common interest 47,256 miles (the roads of these two latter classes traversing several communes or towns), ordinary vicinal, which are located within a single commune, 177,550 miles; rural roads, which are unimportant neighborhood roads 155,376 miles. It is estimated that the national roads cost $12,400 per mile for construction and $285 per annum for maintenance; the department roads $7750 per mile for construction and $166 per annum for maintenance; the vicinal roads of through travel $6200 per mile for construction and $121 per annum for maintenance; the vicinal roads of common interest $3750 per mile for construction and $102 per annum for maintenance; the ordinary vicinal roads $2470 per mile for construction and $49 per annum for maintenance. The national roads are constructed and maintained entirely at the expense of the national government, which also aids by subsidies to a small extent, the vicinal roads. The departments maintain the department roads. The national government has general jurisdiction over all transportation facilities and direct supervision over the national roads, which are administered by the corps of bridges and roads in the ministry of public works. The corps of bridges and roads is divided into three divisions, of which roads and navigation form one.

The division of roads and navigation is under the direction of a counselor of state and is divided into two sections, namely; bridges and roads, and navigation. The section of bridges and roads is divided into two bureaus, one of which has entire charge of the national roads, and the other has jurisdiction over all matters relating to department roads, automobile traffic and general police regulation. The sections and bureaus and the higher field inspection are under the direction of inspectors general. Each of the inspectors general of the second class have charge of a large field division and under him engineers in chief, usually one to each department, while under these engineers in chief are ordinary engineers and under them are sub-engineers and conductors or foremen and finally the patrolmen who work directly and constantly on maintenance, each having a section of road varying in length, but averaging about 2.8 miles. There were 8560 patrolmen employed in 1909 on the national roads. The engineers for the French road service are trained in the School of Roads and Bridges at Paris and are appointed upon graduation to the lower positions and gradually advanced to positions of responsibility.

The annual expenditure on the public roads of France is about $48,000,000. The national government appropriated in 1910, $9,720,000 for the national roads. It is estimated that the total cost of the entire French road system, excluding the unimportant neighborhood roads, is upwards of $1,663,000,000.

Germany

The imperial govermnent of the German Empire takes no part in the construction or maintenance of public roads. Each state in the Empire follows its own policy in this matter.

As a general rule the roads in the various states are divided into three classes: state or provincial roads; county roads, and local roads. The state roads are generally built and maintained by the state, which maintains a corps of competent engineers. The larger states usually divide their road systems into districts, the engineers in charge of the districts reporting directly to the central office. The patrol system is quite generally followed, each patrolman having from 2 to 5 miles of road to maintain. Their compensation is from $150 to $250 per annum. At the end of thirty years service, or if sooner incapacitated, they are entitled to a pension.

Prussia takes no direct part, however, in the maintenance of roads. The state roads were turned over to the provinces in 1875 and some of the provinces in turn passed them on to the counties. The general government grants aid to the provinces by certain allowances from the "donation fund."

The largest class of improved roads in the German Empire is that of the county roads which are very largely maintained by local taxation. The states and provinces, however, exercise close supervision over these roads. The parish roads are purely local and are maintained and managed by the parishes, although occasionally the county and even the province aid in new construction.

There are approximately 36,000 miles of state road in Germany, of which Prussia has 20,489 miles, Bavaria 4200 miles, Saxony 2267 miles, Baden 1890 miles, Württemberg 1710 miles, and the smaller states the remainder. Of county roads Prussia has 38,400 miles hard surfaced, parish roads 14,598 miles hard surfaced, and private roads 1100 miles hard surfaced, or a total of 74,587 miles of improved roads, or 1 mile for each 1.8 square mile of area. Prussia expends nearly $35,000,000 a year on all roads, of which about 28 per cent is paid by the provinces, 33 per cent by the counties and 39 per cent by the parishes. Under favorable conditions the cost of construction of state roads does not often exceed $5000 per mile. In Hannover a considerable mileage of brick roads has been constructed at from $10,000 to $13,000 per mile. In the kingdom of Württemberg the cost of maintenance of state roads in 1910 was $400 per mile.

Italy

The roads of Italy aggregated 92,199 miles in 1910, and were divided into three classes, namely, national roads, connecting important cities and ports; connecting with roads of other countries; the Alpine and Apennine roads, and those used for military purposes, having a total mileage in 1910 of 5159 miles; the provincial roads, connecting the chief town of each province with the chief towns of other provinces and with maritime ports, having a total of 27,757 miles; communal roads, which are the roads of local interest, having a mileage of 59,283 miles. The national roads are constructed and maintained by the national government through the department of public works. The official in charge is designated as the director general of bridges and roads. The provincial roads are constructed and maintained by the provinces, while the communes or townships provide for the construction and maintenance of communal roads. The national roads are maintained by means of the patrol system, each patrolman having an average of 2½ miles of road. It is estimated that the cost of maintenance in 1909-10 was $274.70 per mile per annum for national roads, and $183.32 per mile per annum for provincial roads.

Norway

The roads of Norway aggregate 17,550 miles and consist of main roads, 6570 miles, and district roads, 10,980 miles. The national government contributes two-thirds to three-quarters of the cost of construction of main roads, while the maintenance of such roads is, with few exceptions, a local burden. The work is done under county engineers who are nominated by county councils and appointed by the national government. At the head of the whole system, however, is the national road director. It is estimated that the main roads cost about $8000 per mile.

Russia

There are 11,254 miles of post roads in Russia, of which 8326 miles are under direct government control and 2928 miles are temporarily under control of district councils with government supervision. The construction and maintenance of these government roads are partly under the ministry of ways and communications, and partly under the war department. It is estimated that the cost of construction of government roads is from $8544 to $10,874 per mile, and the maintenance from $70 to $210 per mile per annum.

Spain

There were 33,873 miles of road in Spain, in 1910, which were classified as state roads and provincial roads. State roads are constructed and maintained by the general government through the department of public works. Under this department is a director general, and under him a chief engineer for each province. The government also aids, by appropriations, maintenance of provincial roads. The patrol system is followed in the maintenance of state roads. It is estimated that the maintenance of state roads costs between $230 and $240 per mile per annum.

Sweden

There were 35,450 miles of road in Sweden, in 1907, made up of 11,850 miles of main roads and 23,600 miles of district roads. The main roads are those which unite the kingdom with other countries and connect the large cities and ports. The district roads are those of local importance. For the construction of main highways, the government pays two-thirds and the districts one-third of the cost, while on maintenance of these roads, the government pays 15 per cent of the total. The royal board of road building and water works has supervisory powers in road, railroad and harbor construction. The expenditure per mile of road, including all classes, was in 1907, $60 per mile.

Switzerland

There were in 1911, 7426 miles of road in Switzerland which were classified as federal aid canton roads built and maintained by the cantons with federal aid, 350 miles; canton roads, built and maintained by cantons, 862 miles; municipal roads built and maintained by municipalities 6214 miles. The federal government grants aid only to those four cantons whose roads are of international character, the annual aid being as follows: Uri, $15,440; Graubunden, $38,600; Tessin, $38,600; Valais, $9650.

The department of public works in each canton supervises road construction and maintenance, while the upper supervision of the federal government is carried on through the department of the interior. Construction of roads in Switzerland is very expensive on account of the fact that they are practically all mountain roads.

PART II

The Construction and Maintenance of Rural Roads

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LOCATION, GRADES, WIDTHS AN DCROSS-SECTIONS OF RURAL ROADS

The improvement of any road or system of roads must begin with a study of its location and grades, for unimproved roads are often bad in both respects. The purpose of relocation is to enable the road to carry the anticipated traffic with the least effort and loss of time. It is impracticable to relocate all roads and improve their grades at the present time, and highway officials must be satisfied with gradually eliminating or at least reducing the defective conditions. In order to carry on this work efficiently, however, the entire system of roads under a board or commission must be studied as a whole, so that the whole body of taxpayers may be benefited as uniformly as practicable by the work done annually. The work should be planned in a broad way several years in advance, if possible, for it is only in this way that the needs of all parts of the district can be met without favor or prejudice. This is particularly important where the needs are great, the road funds meager, and property has been developed along locations where roads should never have been laid out. The situation in such cases has been summed up as follows by W. S. Keller, State highway engineer of Alabama:

> The genuine bad roads cannot be maintained for the reason that they have never been constructed. The great amount of work necessary to keep them in passable condition disheartens the man who is by law compelled to work them. Until these roads are relocated, avoiding heavy grades and marshy bottoms, sharp angles and useless twists, and are graded so they will have good drainage, we may expect them to be bad.

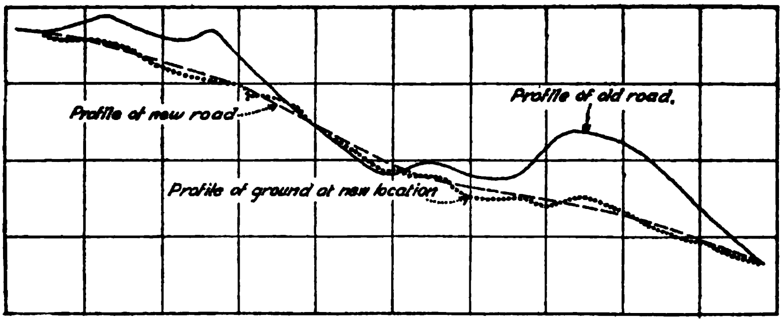
Location.—It is evident that the road should be as nearly straight between the points it connects as the configuration of the country traversed will permit. It is desirable, however, to restrict grades to 6 per cent and to avoid expensive cuts, fills and bridges. To locate the road properly and meet all local conditions in the best manner requires competent engineering services; if they are not obtained there is a strong probability that after the country develops new locations must be made to meet the increased transportation needs and the expenditures for new rights-of-way will be far greater than to-day. But if, for the present, engineering services are out of the question, the road authorities can at least relocate roads that are plainly unnecessarily low and marshy and unnecessarily steep and high. This is particularly the case where roads have been laid out on the section lines of the government land surveys. However desirable the rectangular parceling of unoccupied land may have been in attracting settlers, it has proved a heavy handicap on transportation by introducing many right-angle turns and causing needless length in the roads of these regions. The following comment on this condition was made by W. S. Gearhart, State engineer of Kansas:

> A 60-foot road on two sides of a section of land occupies 14.55 acres, while a road 60 feet wide in a diagonal direction through the section occupies 10.28 acres. Thus there is a saving in the diagonal road of 4.27 acres and 0.587 mile of distance. The saving in the cost of right of way, assuming that the land along the section line is as valuable as on the diagonal line, is $85.40 if the land is worth only $20 per acre. This amount in most cases would be sufficient to grade the 1.413 miles of diagonal line in first-class condition. If a man lives 4 miles north and 4 miles east of his market-place he is 5.657 miles on the diagonal line from it; that is, on the section-line road he must travel 4.686 miles farther in making the round trip than on the diagonal line.

The same official has reported that a county commission built a mile of road on a section line, which crossed the same stream three times. By adopting a somewhat different location and making the road 1¼ miles long, the stream would be crossed but once and the road become of greater service to the community. "More than $3,000 worth of steel bridges were bought, it will cost not less than about $2,500 for the abutments to set these three structures on, and an expenditure of $2,500 will be necessary to make the road passable, or a total of about $8,000 to accommodate four men whose property is reported as probably not worth as much as the cost of the road." Instances of this nature prove the desirability of having roads located by engineers without interference from political or personal influences. The assertion that such services are unnecessary in connection with such relatively inexpensive highways as dirt roads is best answered by pointing to the action of the Utah State road commission in substituting an entirely new location about 15 miles long for an old route in Beaver County. This was done by the engineers because the new line had better alignment, grades and road materials.

The influence of soil conditions and the presence or absence of road materials may not be given due consideration in locations made by persons who are not engineers. The following comments on this point were made by A. N. Johnson in a report on the highways of Maryland:

Should it happen that two locations are possible with about equal advantages and disadvantages, except that one was over a different soil from the other, that location should be taken which traverses the soil best calculated to insure a good road-bed. For example, if it were possible to avoid going through a clay section when a more open soil could be had close at hand, much would be saved both in the cost of construction and in the subsequent maintenance by going over the more open soil. It is hardly necessary to state that crossing soft, boggy soil should be avoided whenever the expense of going around such a place would be no more than for crossing it. If possible it is always well to locate a road in the vicinity of good road-material, either a suitable stone or gravel, for the proximity of such material lessens for all time the cost of maintenance of the road, and when this point is considered such a location would be warranted even at an increased first cost.



PROFILE OF ROAD IN BALTIMORE COUNTY, MD.

Showing How Relocation Saved a Large Sum in the Improvement of the Road.

Value of Engineering Services.—Few persons realize that the expense of engineering services in relocating old roads is generally more than offset by the saving in the cost of construction of a properly located road over one improperly located. The engineer knows how to fit the road to the ground in hilly country so that the material from the cuts may be used in making nearby embankments and costly rock excavation will be reduced to the lowest practicable amount. On the Maryland State highways, the expense of moving 100 to 150 cubic yards of earth is from $50 to $75, which is equal to the cost of making a mile of careful surveys that may be reasonably expected to save more than 150 cubic yards of such earthwork. The accompanying illustration shows the saving in excavation expenses on a road in Baltimore County, Md. The hilly character of the old road made necessary heavy reductions in grade to give a highway properly accommodating the traffic. The heavy cutting to give suitable grades along the old location is shown by the diagram, while the light excavation and filling required on the new location is also indicated. Such savings of cost can only be made by competent engineers. The amount of detail which the engineers' survey must furnish depends on the character of the road to be built and the nature of the country. Less detail is necessary for an earth road in a flat country than a brick road in a hilly district, for example, but enough should be obtained to make sure that the final location is along the line on which the cost of transportation plus the interest on the first cost plus the cost of maintenance of the road will be the minimum for the available funds for first cost.

The last point is important, for the best location is often governed by the amount of money which can be spent on construction.

In carrying out extensive work by contract, experience shows that low bids from responsible contractors are best secured when full information is obtained for their use in preparing estimates. For instance, in carrying out road improvements in Vermilion County, Illinois, under a $1,500,000 bond issue, about 1800 drawings of plans, profiles and cross-sections were prepared in the first two months of the work. These were plotted on Plate A 4 by 20 profile paper cut into 32-inch lengths. The longitudinal scale of the plans was 80 feet to 1 inch and the tranverse scale 40 feet to 1 inch. The horizontal scale of the profiles was 80 feet to 1 inch and the vertical scale 4 feet to 1 inch. The plans show all section corners, bench marks, fence lines, shade trees, farm entrances, property owners' names, drains and culverts to be built, and any other data necessary for a complete knowledge of the working conditions. The cross-sections are plotted on a scale of 4 feet to 1 inch. An 11 by 8½-inch map was made of the location of 14 sources of sand and gravel, the plants furnishing paving brick and the railways running from them to the district where the roads were to be built, and 24 by 20-inch maps were made showing the roads, railways and sidings available for contractors' use. The existing road grades were shown on small maps, and other small maps showed the location and size of proposed bridges and culverts.

Grades.—The effect of grades on hauling is usually stated in the following manner: If a horse can pull 1,000 pounds on a level road, he can pull 810 pounds with the same effort on a 2 per cent grade, 720 pounds on 2½ per cent grades, 640 pounds on 3½ per cent grades, 540 pounds on 4 per cent grades, 400 pounds on 5 per cent grades and only 250 pounds on 10 per cent grades. These figures are only approximate but they show the importance of reducing grades as much as possible where traffic is heavy. Where traffic is not heavy, the cost of reducing grades below 3 or 4 per cent, if it must be done by expensive construction or considerable lengthening of the road, is generally considered an unwarranted expense.

A thoroughly consolidated roadbed is a valuable public asset and in planning grade improvements it is sometimes undesirable to cut 6 to 12 inches into such a road for a long distance in order to secure a theoretically perfect profile.

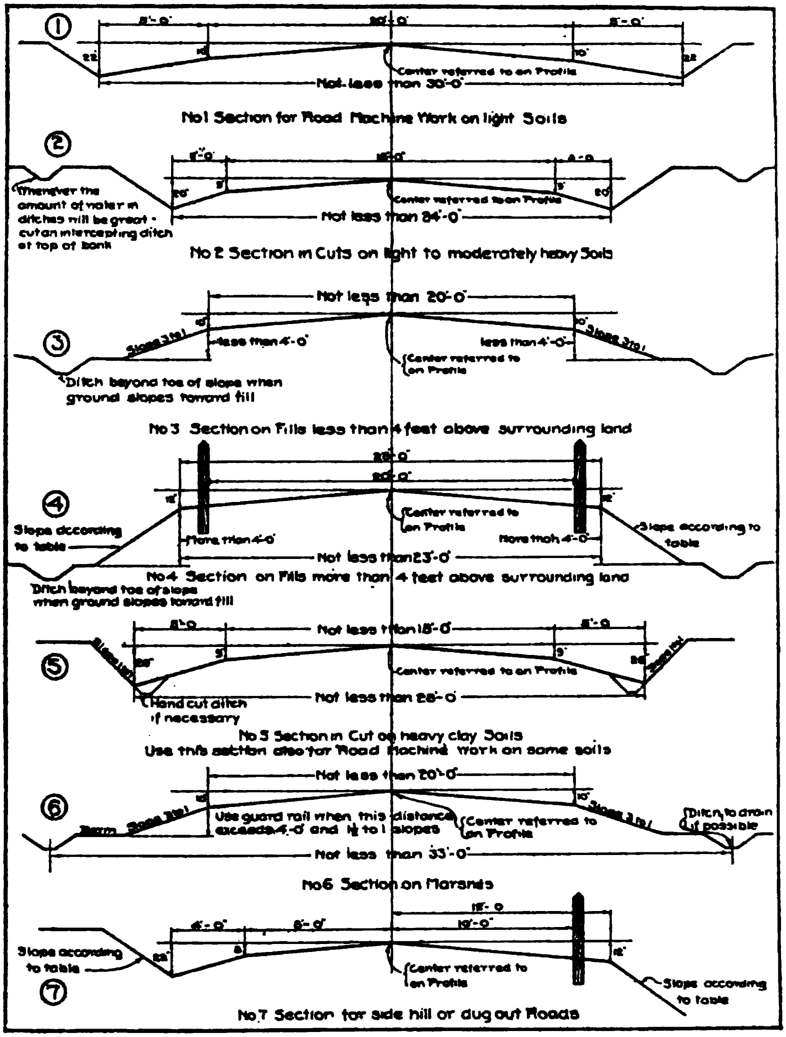
Where a road will probably have considerable automobile traffic the grades up a hill should be flattened somewhat at the top if necessary, so the driver can see an approaching car when it is 300 feet from him. When the change in grade at the summit is not more than 6⅔ per cent, no flattening is necessary. If the change is 10 per cent a vertical curve about 200 feet long should be employed; for a 13 per cent change, a curve 292 feet long and for a 16 per cent change, a curve 360 feet long.

Widths.—Highway commissions in many parts of the country are reporting that their roads are often too narrow to accommodate the traffic coming on them as soon as they are improved. State Highway Commissioner Everett of New Hampshire reports that the standard width of 21 feet from ditch to ditch is not wide enough on many of the roads under his jurisdiction, and the experience of the Wayne County road commission, in Michigan, shows that the minimum width of hard-surface roadway in the district around Detroit should be 16 feet and 18 feet, and should be adopted wherever practicable. These comments relate to double-width roads. A width of 8 feet, previously used for single-width roadways, is now generally considered too narrow and 9 and 10 feet are advocated.

Many of the State highway departments have established standard cross sections for earth roads. The present standards in Wisconsin are shown in the diagrams on the next page. They are also the standards for macadam and gravel roads having a hard surface 9 feet in width. Where the slopes are not indicated they are made in accordance with the accompanying table. Guard rails are used when the vertical distance from the edge of the shoulder to the top of the ditch is more than 4 feet.

Slopes Required by Wisconsin Commission in Road Work in Different Kinds of Soil

SOIL	ALL CUTS	FILLS LESS THAN FOUR FEET	FILLS OVER FOUR FEET
Sand and sandy gravel	2 to 1	3 to 1	2 to 1
Loam	1½ to 1	3 to 1	1½ to 1
Clay and clay gravels	1 to 1	3 to 1	1½ to 1
Hard pan	½ to 1	3 to 1	1 to 1
Solid rock	As it stands	3 to 1	As it stands


①
8'-0"
30'-0"
8'-0"
22"
10"
10"
22"
Center referred to on Profile
Not less than 30'-0"
No1 Section for Road Machine Work on light Soils
②
8'-0"
18'-0"
8'-0"
20"
9"
9"
20"
Whenever the amount of water in ditches will be great - cut an intercepting ditch at top of bank
Center referred to on Profile
Not less than 34'-0"
No2 Section in Cuts on light to moderately heavy Soils
③
Not less than 20'-0"
10"
10"
Slope 3 to 1
Slope 3 to 1
less than 4'-0"
less than 4'-0"
Center referred to on Profile
Ditch beyond toe of slope when ground slopes toward fill
No3 Section on Fills less than 4 feet above surrounding land
④
28'-0"
20'-0"
12"
12"
Center referred to on Profile
Slope according to table
Slope according to table
More than 4'-0"
More than 4'-0"
Not less than 23'-0"
No4 Section on Fills more than 4 feet above surrounding land
Ditch beyond toe of slope when ground slopes toward fill
⑤
8'-0
Not less than 18'-0
8'-0
Slope 1 to 1
Slope 1 to 1
26"
9"
9"
26"
Center referred to on Profile
Hand cut ditch if necessary
Not less than 28'-0
No5 Section in Cut on heavy clay Soils
Use this section also for Road Machine work on some soils
⑥
Not less than 20'-0"
10"
10"
Berm
Slope 3 to 1
Slope 3 to 1
Use guard rail when this distance exceeds 4'-0" and 1½ to 1 slopes
Center referred to on Profile
Ditch to drain if possible
Not less than 33'-0"
No6 Section on Marshes
⑦
4'-0"
8'-0"
15'-0
10'-0"
Slope according to table
22"
8"
12"
Center referred to on Profile
Slope according to table
No7 Section for side hill or dug out Roads

STANDARD EARTH ROAD SECTIONS, WISCONSIN

The Wisconsin sections are wide enough to carry a 16-foot roadway. It is now generally held that the distance from ditch to ditch should be 24 feet, even for a single-width road, if local conditions permit. In some States, where the legal right-of-way is only 30 feet, it is impracticable to secure 24 feet between ditches and have proper fences and banks along the road where it is in cuts. It is necessary to obtain extra wide rights-of-way in such cases or to make the road narrow.

It has been claimed that if a hard surface is placed on a roadbed, the width of this pavement need not be so great as when the traffic is carried by a less durable surface, and consequently a smaller width between ditches and less earthwork are required. This argument ignores the fact that a narrow roadway concentrates the travel and may cause the improved surface to carry a volume of traffic for which it is unsuited. For this reason 9 and 10 feet for a single-width surfaced roadway and 16 or 18 feet for a double-width roadway are generally favored. In recent years a new factor has become important in determining the proper width of hard surfacing. Heavy motor trucks and omnibuses are now in regular service on many roads. If they turn off a hard surface on to a soft shoulder they may become mired or unmanageable and crash through fences or guard rails before the brakes stop them. The driver is usually on the left hand of such a truck where he cannot easily see the edge of the hard paving, and consequently he keeps his truck well toward the center of the road in order to avoid trouble on the shoulders, although the driver of a lighter vehicle would keep farther over to the side.

Where the road is used by carts or trucks that make a loaded trip in one direction only, as well as in other sections where funds are not available at present for a double-width paved roadway, an 8 to 10-foot pavement has been laid on half the road, with one side along the center line, as though a similar pavement were to be laid at once on the other side of the road.

Rights-of-way.—The width of the road is restricted in the older parts of the country by narrow rights-of-way, which are troublesome limitations on road improvements. Cuts and fills of more than a few feet widen the strip occupied by the road, ditches and side slopes. Telephone poles and trees along the road require space, and provision for both is desirable. As a result of long experience in Massachusetts and California, reinforced by observation in many other States, Austin B. Fletcher, state highway engineer of California, recommmends securing a minimum of 50 feet for right-of-way, and 60 feet wherever practicable.

Acquiring rights-of-way is an annoying feature of the work of highway commissions, and in any extensive undertaking experience shows that the best results are obtained if the business is handled by one man, with whatever assistance is needed. Diplomatic methods are best but legal warfare is sometimes necessary, and whatever means must be used should be employed promptly in order to have the right-of-way available for construction as soon as it is time to begin work. In some States, it is unnecessary for the authorities to pay for private property taken for public use in advance of actually taking possession. If the property owner is dissatisfied with the original offer of payment or the award made to him by the public authorities, he may pursue his remedy in the appropriate court, even though his land has already been occupied by the public. In other States no rights-of-way can be taken before they have been acquired, after a vast amount of red tape, by donation, purchase or condemnation. The western States are particularly oppressed by such roundabout methods of entering upon private property to carry on improvements for the benefit of the entire community.

It has been Mr. Fletcher's experience that the expense of obtaining abstracts of title to ascertain the ownership of land is unnecessary. The method he has employed in securing rights-of-way for hundreds of miles of California highways is the following: When the field parties are making the original surveys, the chiefs of party usually inquire from the occupants of the land surveyed who the owners or those interested in the property may be. This gives a clue to the ownership. Thereafter one of the staff visits the proper county officers and ascertains from the assessment rolls or the records who purport to be the owners. Deeds or agreements are then prepared, containing the proper descriptions, and it is very rare, indeed, that any objection has been made to the accuracy of the instrument submitted. By thus performing its own title searches, even though thay may not have always been the most exact from a title lawyer's standpoint, the authorities have saved thousands of dollars and have never had an injunction or ejectment proceeding instituted against them by objecting land owners.

Curves.—Sharp curves and right-angle intersections are danger places where vehicles move rapidly. The width of the roads should be increased on sharp curves, except where it is already wide, and the right-of-way at right angle intersections should be widened and cleared so as to give drivers on the crossing roads a good view of approaching vehicles. This is not always practicable, unfortunately, but road commissions should keep in mind that these places are dangerous, that it is their duty to reduce the dangerous conditions on the roads under their charge and that it is less expensive to improve these places now than it will be later.

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On curves on a road with a uniform cross-section there is a tendency for the drivers of motor vehicles to stay on the inside of the curves because the centrifugal effect of passing on the outside is unpleasant. In order to make motor travel equally agreeable on any part of the cross-section of curving roads, it is now the practice to superelevate the outside of the road, as is done on railways. Experiments with different angles of superelevation on California roads have led the highway department of that State to adopt a slope of ¾-inch rise to each foot of width of the roadway on all curves having radii of 300 feet or less. The transition from the standard crowned cross-sections to the uniform transverse slope stated is made in a distance of about 80 feet. In passing from the straight to the curved road, the outside of the road is gradually made horizontal and then gradually tipped up until there is the same slope throughout the section from the inside to the outside edge. In this transition the inside edge remains at the same elevation it would have if the ordinary crowned cross-section were maintained; the change is made by adding to the height of the other parts of the standard section, so the improvement is generally called "banking the curves."

Grade Crossings.—The elimination of grade crossings is a problem that frequently complicates the location or relocation of highways. The usual method of carrying the road under or over the railroad tracks is so costly that its general use on rural roads is impracticable. Some of the narrow underpasses with sharply curving approaches that have been built on roads used by numerous automobiles at high speed are almost as dangerous as the grade crossings they replace. Attention is therefore being given more and more to comprehensive relocation as a means of reducing the number of grade crossings and making those remaining less dangerous than before. For example, there was a Wisconsin road 23.9 miles long with 16 grade crossings and 15 such crossings on branch roads feeding it, in addition to 3 underpasses and 2 overhead bridges. A careful study by the State highway commission showed that by reasonable relocation the total number of crossings could be reduced to 16 at grade, 4 underpasses and 2 overhead bridges, and the 16 grade crossings would be on the branch roads, none remaining on the main road. The total cost of right-of-way and construction for such an improvement was estimated at $35,000, much less than the cost of elimination in the usual manner.

The New York State highway department has had a long experience in treating grade-crossing problems and as a result has adopted the following general rules for location at such crossings:

1. The alignment should be laid out so that approaches are on a tangent which is at least 400 feet long, 200 feet on each side of the crossing. The angle that the highway makes with the railroad should not be less than 60 degrees. The grade of the approaches should not be greater than 6 per cent, and there should be a portion level or nearly so for a distance of not less than 100 feet on each side of the crossing.

2. On the highway within 200 feet of the railroad, on each side, traffic should have a clear view of approaching trains for a distance of 1,000 feet. (See Rule 5.)

3. The width of the planked crossing shall not be less than 24 feet, measured at right angles to the center line of the highway. The ends of the pavement should be protected by an edging of stone or concrete placed at a sufficient distance from the ends of the ties to allow for replacing them.

4. A standard danger sign should be placed at each side of the crossing along the highway in a prominent location at least 400 feet from the crossing.

5. When the view of the railroad either way, as required in 2, is less than 1,000 feet, or when there is a great deal of traffic on either the highway or railroad, or when vision may be blocked by cars or trains as in the case of a railroad with two or more tracks, a flagman should be employed to warn highway traffic.

The New York State highway department's rules for the elimination of grade crossings are as follows:

1. Subways shall have a clear head-room of not less than 13 feet and a clear width between abutments of not less than 26 feet. The approaches when in a cut shall have a minimum width of 28 feet between bottoms of slope. When a highway passes over a railroad the clear height over said railroad shall be not less than 21 feet and the approaches when on embankment shall be not less than 28 feet wide across the shoulders.

2. The alignment and grade of approaches shall be such that traffic at any point within the limits of the elimination will be able to see that approaching it for a distance of 300 feet. The maximum allowable grade shall be 6 per cent.

3. Bridges carrying railroads over highways shall be of a solid-floor, ballasted type. Drainage of such floors shall be such that water will not drop upon the roadway. Bridges carrying highways over railroads shall have solid concrete floors with a minimum width of roadway of 18 feet.

4. When an elimination is made on a highway already improved, the pavement shall be of the same type as the existing pavement. If the highway is not improved the pavement shall be the same as that contemplated.

5. Subways shall be drained in a thoroughly satisfactory manner.

6. The limits of an elimination shall be taken as the points of intersection of the approach grades of the elimination with the grade of the existing highway.

REGULATIONS OF THE CALIFORNIA HIGHWAY COMMISSION REGARDING SURVEYS AND PLANS[1]

Part 1. Surveys

(a) *Note Books.*—Survey note books will be furnished to the chief of party by the Division engineer. No survey note book other than the standard book so furnished shall be used, and the use of loose sheets is prohibited. The notes placed therein shall be the "original" notes of the survey and shall not be copied from sheets or from other books.

The standard book shall be used for alignment, topography and levels, and for all other information which the survey parties are required to secure; all notes shall begin at the bottom of the page and read upward.

On beginning a survey the chief of party shall see that a proper entry of the Division, county and route, is made upon the label pasted to the inside of the front cover of the note book.

Attached to the back cover of each book are several pages showing the "standards" required in all surveys. All survey notes shall conform in so far as possible to such "standards" to the end that all surveys and the manner of taking the notes thereof shall be uniform throughout the work.

At the beginning of each day's work the following data shall be entered in the book: Date; weather conditions; names of members of party and duties of each.

When no notes are taken on a working day or portion of a day, the date shall be entered and the reason for the loss of time shall be stated clearly and concisely.

All survey and other notes shall be suitably indexed on the first ruled page of the note book.

Every day at the close of the work the notes shall be copied neatly upon specially printed sheets furnished by the division engineer and numbered consecutively, and after careful checking such sheets shall be forthwith forwarded to the division engineer.

No note book shall contain notes relating to more than one route or to more than one county.

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[1] From Austin B. Fletcher, State Highway Engineer of California.

(b) *Alignment Notes.*—The base line of the survey shall be referred to the true meridian, which shall be determined by observation on polaris. The chief of party before beginning a survey shall procure all tables and other data needed for such determination and observations shall be made from time to time to ensure the accuracy of the work. The line shall also be checked by magnetic bearings taken at each transit point. All angles in the base line shall be azimuth angles read from the back sight and repeated with the telescope reversed.

Complete traverses shall be run in all surveys and computed in the field. If the error of closure exceeds 1: 5000 the division engineer shall be notified and the party shall not move camp until he has authorized such moving. The closures shall be completed and computed in such lengths as the division engineer shall prescribe.

The base line shall be as nearly as may be in the center of the proposed road. When it is apparent that a tangent base line will not follow the approximate center of the proposed road, a curve of suitable radius shall be run. Curves shall be measured by computing the length of the arc and not by chords.

If the survey follows an existing road, wire nails not less than 5½ inches in length shall be driven flush with the traveled way at all angle points in the base line, at the beginning and ending of all curves and on long tangents at intervals not exceeding 1000 feet.

When the base line does not follow a traveled way or when the roadway is so soft that nails will not hold their position, wooden stakes driven flush with the ground shall be used and the transit point indicated thereon by a small nail.

All transit points shall be properly referenced as provided under the caption "Stakes."

Stations shall be established every 100 feet on the base line and indicated by short wire nails driven through bits of red cloth into the ground to serve as temporary markers during the survey. The stations and half stations shall be also permanently marked by stakes set on both sides of the proposed road sufficiently far removed from the base line to prevent their being disturbed during the building of the road.

(c) *Stakes.*—All stakes which are to be used for establishing grades shall be made from 2 x 3 inch scantling, from 24 to 30 inches in length, laid flat and sawed diagonally into two wedges, with the sharp ends approximately ¼ inch thick. The lumber from which the stakes are made shall be sound, reasonably free from knots, and planed on all sides. These stakes shall be driven into the ground to about one-half of their length with the 2-inch face parallel to the base line. On the right side of the road the station number shall be marked plainly on the side of the stake facing Station O, and on the opposite side of this stake shall be marked to the nearest tenth, the offset from the base line. The face toward the road must be reserved for marking during construction. On the left hand side of the road, the offset from the base line shall be marked on the side of the stake facing Station O and the station number on the opposite side.

All stakes used to mark monuments and for transit points shall be wedge shaped, not less than 1 foot in length nor less than ⅞ x 2-inch at the top. Such stakes shall be driven flush with the ground unless they are so located as not to endanger the traveling public. Short nails driven into the tops of these stakes shall indicate the monument and transit points.

All monument and transit points shall be referenced by three ties to natural objects or, if such do not exist, to stakes, as shown by the "standards" at the back of the note book.

(d) *Topography.*—All objects, such as houses, barns, fences, gates, field entrances, trees, telephone and telegraph poles, power lines, railroad and railway tracks, within a distance of 150 feet on either side of the base line shall be located by offsets from the base line and recorded in considerable detail, and the limits of the "traveled way" on all existing roads shall be indicated. Separate sketches, with levels and dimensions of all essential features, shall be made in the note book of all bridges, large culverts and other appurtenances of the road, and plainly referenced in the topography notes.

The azimuth from the back sight to the boundary lines of all incorporated cities and of all counties shall be ascertained and recorded. The azimuth of the boundary lines of all entering and intersecting highways, of township lines, and of division lines between property holdings shall be ascertained and recorded with reasonable accuracy, and when feasible the names of the owners of property abutting on the proposed road shall be recorded.

When it is desirable to locate topographic features from a sub-tangent, the station will be measured from the nearest end of the curve.

(e) *Levels*—Whenever there is a known government bench within 3 miles of the survey, the datum plane of such bench shall be adopted for the work. If no such bench is available, a datum plane shall be assumed at such an elevation as will be low for all parts of the survey.

Benches shall be established during the progress of the work at each end of the survey, at city and county lines, and at other convenient points not more than 1000 feet apart, and at shorter intervals on grades.

Where no permanent objects or structures exist, a long, substantial stake shall be driven firmly into the ground and properly referenced.

On bench marks, at turning points, and on construction stakes, elevations shall be determined to hundredths of a foot.

Cross section levels shall be taken to tenths of a foot at each 100-foot station and at half stations, at entering and intersecting roads, for not less than 200 feet from the base line, at driveways and field entrances and wherever the surface of the ground changes abruptly. The elevation of the center of the traveled way of an existing road shall be taken and properly noted when it does not coincide with the base line. The cross sections shall include the whole width between fences, and where the grade is likely to be changed substantially the cross sections shall cover a width sufficient to include all ground likely to be affected.

Sections shall be taken at all culverts and water crossings, and elevations shall be taken a sufficient distance up and down all streams to afford data for designing new structures.

(f) *General Data.*—The survey notes shall contain data concerning:

1. The location of outcropping boulders and bedrock, suitable for road metal or concrete.
2. The location of all quarries near the proposed road.
3. The location and approximate quantity of field stone available in the vicinity of the road.
4. The location of all gravel pits.
5. The location of points where good river sand can be obtained.
6. The available points where water for sprinklers and steam rollers can be obtained.
7. The location of all railroad spur tracks or sidings within reasonable haul of the proposed highway and the name of the railroad.
8. The most advantageous locations for rock crushing plants along the road.
9. The current wages paid to teamsters and laborers in the locations through which the road will pass. Amount paid for hire of mules or horses (without driver) per day. Amount paid for man and two-horse team per day.
10. The locations where special underdrains should be installed due to the existence of unstable sub-soil conditions. Inquiry should be made of residents and local officers regarding spots that break up badly in wet weather.
11. The approximate area of the watershed at each stream crossing if it can be readily obtained. All high-water marks should be noted and inquiry as to whether or not water overflows the road.
12. All general information that may prove of value in the construction of the highway.

Part II. Plans

(a) *Drafting.*—All drafting so far as possible shall be done in the division offices. At the Sacramento headquarters, the drafting shall be limited to work of a general nature, such as the design of standards, general maps and to such revision work of the plans made in the division offices as may be necessary. No drafting shall be done in the survey party camps except such as is immediately needed in the mountainous country to facilitate the choice of lines and grades.

The plans, profiles and cross-sections shall be plotted in the division offices from the copies of the survey notes sent in daily by the survey parties as required under the rules for surveys.

(b) *Working Plans.*—The plan and profile of every road survey shall be plotted on detail paper 30 inches in width and of such length as may be found convenient, the plan to be plotted above the profile, and such drawings shall be known as the "Working Plans."

Plans and profiles shall be plotted from left to right, the plan on the scale of 1 inch to 100 feet and the profile to the same horizontal scale and to the vertical scale of 1 inch to 20 feet.

The base line of the survey shall be plotted by coordinates obtained from the traverse sheets which have been made and calculated in the survey camps and said base line shall be inked in red before the topography is plotted. All angles and curve points shall be marked by small circles, and the even stations by a line ⅛ inch in length drawn at right angles across the base line.

The even stations and the plus distance of all angle and curve points shall be numbered below the base line. The calculated bearings of the base line, together with the tangent and curve lengths and the radii of the curves, shall be indicated above the line. The right-of-way lines shall be shown in red. They shall be properly referenced to the base line and land corners. Where they are not parallel to the base line their bearings and lengths shall be indicated. The topography and lettering other than that relating to the base line shall be done neatly and so as to permit of tracing easily but such details shall not be inked.

All drafting details shall conform to the conventions shown on the specimen sheet furnished to each drafting office.

The north point shall be indicated at intervals of not more than fifty stations.

The datum line of the profile shall be drawn ¾ inch from the bottom of the sheet and inked in black. Perpendiculars shall be erected at each even station and inked in black. The even stations and plus distances shall be numbered below the datum line and the elevations of the present surface of the ground shall be shown above the datum line and to the left of the perpendiculars. The elevations of the proposed finished road surface shall be shown in red and to the right of the perpendiculars.

The present ground surface shall be drawn in black, and the proposed finished surface of the road and proposed rates per cent of grade in red. Points of change in the rate of the finished grade and the beginning and end of vertical curves shall be indicated by small circles.

No title need be placed on the working plans; they shall be identified by the file number, and such plans shall bear the signatures of the employees concerned in their preparation and the date.

(c) *Cross Sections.*—The cross sections shall be plotted to the scale of 1 inch to 5 feet vertical and horizontal on specially ruled sheets, 20 by 30 inches in size, furnished by the highway engineer. They shall be plotted from the bottom of the sheet upward and so as not to interfere with one another more than is necessary. The station numbers shall be placed directly below the datum line and across the base line. The present ground surface, the elevation at the base line and the station number shall be inked in black. The proposed finished surface, together with the elevation at the center of the proposed roadway, shall be shown in red.

(d) *Layout Plans.*—The layout plans shall be on tracing cloth 20 by 30 inches in size and the first sheet shall carry the title, small index or key maps, conventions, and the necessary certificates and signatures, and such sheet will be prepared in Sacramento. The subsequent sheets shall be traced from the working plan, shall be authenticated by the signatures of the division engineer and the highway engineer, shall state the whole number of sheets in the set and the number of the individual sheet, the file number, and on each sheet shall be shown the true North Point. These plans shall conform as closely as is practicable in workmanship and appearance to the specimen sheet hereinbefore referred to.

(e) *The Grade Line.*—The grade shall be established tentatively on the profile under the direction of the division engineer and transferred to the cross-sections and the proposed finished surface of the roadway and slopes shall be drawn on the sections with the aid of templets to be furnished by the highway engineer. If it appears to be desirable to shift the center of the roadway from the base line, the new alignment shall be located on the working plan by a dotted redline. The limits of earth work shall be shown on the plan by a dotted red line where they extend beyond the fences or known right-of-way lines.

After the grade line has been so tentatively established and the estimates have been completed, the working plan, cross-sections and estimates, together with sketches of special structures, shall be submitted to the highway engineer for his scrutiny.

(f) *Accessions.*—Every plan made in a division office and which is to remain there after it has been signed by the division engineer, shall be entered in the "Accession Book" and described as required by the captions therein. All other plans and maps received at such offices, and which are to remain there, shall be likewise entered in said book.

(g) *Filing of Plans and Note Books.*—All plans shall be filed flat in drawers in the division offices but during their preparation the working plans may be rolled and folded afterward.

When completed, the layout plans shall be filed at Sacramento headquarters and on the completion of a contract the cross-sections shall be likewise filed at Sacramento, blue prints thereof being furnished to the division offices.

All note books shall be filed at Sacramento when the contract relating to the surveys therein is completed.

All documents, whether plans, books or papers, which relate to road contracts shall be stamped with the file mark adopted.

DRAINAGE, CULVERTS AND BRIDGES[1]

In most parts of the country water is one of the most destructive influences on roads. When it collects on the surface it tends to injure the roadway unless the latter is paved with some hard, impervious material. The mudholes on earth, gravel and broken stone roads become soft, so that traffic increases their area and depth rapidly. The impervious crust is finally broken through, allowing water to reach the roadbed, which gives way under heavy loads and the condition of the roadway becomes very bad. If water collects in the ditches, it percolates sideways into the roadbed, softening it and eventually causing subsidence which produces marked irregularities in the surface, so that mudholes form there. If the subgrade on which the roadbed is carried is soggy, a road can not be maintained on it. Charles J. Bennett, State highway commissioner of Connecticut, has reported an instance of this in a city where a 7-inch broken stone roadway was placed on a poorly drained clay subgrade. The roadway broke up when frost came out of the ground and became so impassable that stringers were laid on it and covered with crossplank to furnish a driveway. This heaving action of frost will eventually destroy any roadbed in which water is allowed to collect. The water expands every time it freezes. The expansion opens up the earth, so that gradually more water enters it and finally there is so much in the pores and cracks that its expansion throws up the roadway.

Troubles with water are particularly noticeable on grades. The water is not shed so quickly from the roadway on steep slopes as it is on fairly level roads, but runs toward the side ditches at an acute angle with them. If there is any check to the flow at the side of the roadway, such as irregularities of the surface or vegetation offer, some scouring will eventually take place, and it is for this reason that the good condition of the shoulders of steep roads is important. The scouring of ditches on steep grades is a common occurrence after heavy rains, and experienced maintenance men regard it as an injury that must be repaired immediately. If the road is on a fill and also on a grade, the handling of water requires special care if heavy gullying of the slopes is to be avoided. A gully may be cut a quarter of the way across a new road in such a location by a single heavy rain. An unusual case of the effect of water on slopes has been mentioned by Mr. Bennet. A road which led up a steep hill was originally only wide enough for one vehicle and was the drainage channel for the surface water of the hillside. The surfacing was washed away by every heavy rain. A new road was built by filling in stone to a depth of 4 feet, with an open box culvert at the bottom to carry whatever water might penetrate beneath the road from the sides. This stone fill extended the entire width of the road, from shoulder to shoulder, and very deep, wide ditches were provided at each side. There has been no trouble with this road since it was reconstructed in this way, showing what good drainage can do even in an exceptionally bad place.

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[1] Revised by W. F. Childs, Jr., Resident Engineer, Maryland State Roads Commission.

In any drainage work it is necessary to allow for the different water-holding capacities of different materials. Experiments by the United States Office of Public Roads and Rural Engineering show that with the same condition of dryness, clay will take up more water than sand, but will not part with so much. The rate of drainage from saturated sand is almost twice as fast as from saturated clay during the first twenty-four hours after the materials are allowed to drain. Silt is the slowest material to drain and the loams come between sand and clay. While silt and clay absorb more water than sand, they allow water to percolate very slowly indeed in comparison with sand, and it is for this reason that they form water-tight barriers when confined so their grains can not flow away. When in a loose condition silt permits the smallest amount of percolation, and calling the rate with this material 1 the rate with loose clay is nearly 3, loose sandy loam nearly 28 and loose sand nearly 54. With compacted materials, however, such as exist in a well-built roadbed, the lowest rate of percolation is with clay; calling it 1, the rate with compact silt is 2, compact sandy loam 15, and compact sand 93. The experimental investigations make clear the reason for particularly careful drainage of clay and silt subgrades.

General Methods of Drainage

Road drainage is chiefly a matter of, first, climate; second, topography; and third, soil. It may be treated separately under two heads, surface draining and sub-surface or under-drainage.

In the case of surface drainage, the surface water may be shed in four ways, first, by cross-slope or crown in construction; second, by longitudinal grade after the crown is determined; third, by discharge into natural water-courses; and fourth, by discharge into artificial outlets.

The crown should be determined by, first, character or type of road; second, the locality; and third, by grade. The crown for a natural earth road or a shell road should be made from 1 to 2 inches higher in construction than that which is ultimately desired. This opinion is based on the fact that these types of roads are more susceptible to consolidation and displacement under traffic than most other roads.

In thickly populated districts a high crown is dangerous to traffic and the cross-slope of roads constructed through towns or other thickly populated districts should be reduced to that which is just sufficient to shed water to the gutter line. In such districts high crowns cause a sliding motion of vehicles and bring an extra strain upon lower portion of the wheels which is objectionable and causes public criticism, which, if not considered, brings about a certain amount of prejudice against modern road construction. Finally, in considering crowning of roads the question of grades must not be overlooked. Ordinarily the practice is to increase the crown as the grades become steeper. For all grades up to and including 5 per cent, the crowns mentioned in the next paragraph are considered sufficient. When the grade is in excess of 5 per cent the crown should be so increased that the water will be shed to the side of road rather than run down its surface or, at least, make a curve in its course of final discharge.

The minimum and maximum crowns which it is desirable to use may be determined by multiplying half the width in feet of the hard-surfaced roadway by ½ to 1 inch for gravel roads, ½ to ¾ inch for macadam, ¼ to ½ inch for roads with a bituminous surface, and ⅛ to ⅜ inch for brick and concrete. Formerly curved cross-sections were used with impervious pavements, which were quite flat at the center and increased in curvature toward the sides, with the result that there was a wholly needless slope at the latter. This has been changed of late, and there is a tendency to use uniform slopes from the sides toward the center, where an angle is avoided by introducing a very flat curve. The unpaved shoulders are often given a slope of 1 inch per foot of width.

There are two general methods of draining the roadbed, by side ditches and by underdrains, which will be explained in more detail later. In flat country, the roadbed is best kept dry by raising it above the neighboring land, just as railway roadbeds are raised. If this is not done, it is very difficult to keep roads in good condition.

In undeveloped swamp country, George W. Cooley, State engineer of Minnesota, has found the most permanent roadbeds can be built by constructing the embankment of material dredged from a drainage ditch on the upper side of the road and a smaller ditch on the lower side. When the swamps have soundings of 2 to 5 feet, he considers that the elevation of the bottom of the dredged ditch may be disregarded except that it should not be above the suitable theoretical grade line. This is because the surrounding land is swampy at all times and the subgrade can not be drained by any means short of draining the whole swamp.

In ordinary flat prairie country, the elevations recommended by H. E. Bilger, road engineer of the Illinois highway department, vary with the kind of soil used in the roadbed, as follows: with dense clay or gumbo, where the obtainable grade of the side ditch is less than 0.4 per cent, not more than 800 feet of earth road in one stretch should have its crown less than 12 inches above the adjacent fields, unless the road is along a ridge or on a side hill so that culverts will deliver the water from the uphill ditch to natural outlets on the downhill side. In partly impervious soils, such as loams, the same elevation should be maintained, when the side ditches have a slope of less than 0.2 per cent. With sand, gravel or very loose soil, the crown should be 6 inches above the adjacent fields.

It is troublesome enough to care for the surface and underground water on the right-of-way, without having the work aggravated by water from adjacent property. On hillsides, therefore, the water flowing down the slopes toward the road is often intercepted by ditches along the crest of the cuts, as shown in Cross-Section 2 on page 226, and carried away to suitable outlets. Such ditches are sometimes called "berm ditches." In sections where irrigation is practiced, considerable trouble is sometimes experienced as a result of the overflowing of the road, and to prevent this the following law has been enacted in Colorado:

> No person or persons or any corporation shall cause waste water, or the water from any ditch, road drain or flume, or other place, to flow in or upon any road or highway so as to damage the same, and any such person, or persons or corporation so offending or violating any of the provisions of this section for which there is no specific penalty provided shall pay a fine of not less than $10 nor more than $300 for each offense, and a like fine of $10 for each day that such obstruction shall be suffered to remain in said highway, and shall also be liable to any person, or persons or corporations in a civil action for any damages resulting therefrom; and it shall be the duty of the road overseer in the district in which such violation shall occur to prosecute any person, persons or corporation or corporations violating the provisions of this act.

The water accumulating in the ditches should be discharged as quickly as possible into neighboring outlets. After light rainfalls, this may not seem important, but when a heavy rain occurs in the early spring while the roadway is impervious the need of numerous outlets is evident. This is particularly true on slopes, where a large quantity of water in the ditches is liable to scour them badly. As it is not always practicable to find natural drainage channels on each side of the road, culverts must be built to carry the water under the roadway from one ditch to the other, as well as to provide adequate channels for the brooks crossing the rights-of-way.

Although properly designed and well-built culverts protect a road-bed from injury, it is sometimes desirable to avoid the use of large structures of this class if it can be done by relocating the road. This is particularly the case where the beds of the streams are in alluvial soil which is readily eroded by swiftly moving flood waters. In such cases there is uncertainty whether unpaved channels to and from the culvert will not become so eroded that the structure will settle. Culverts of large size in such localities are comparatively expensive, and if there are many of them it is always well to ascertain if the number can not be reduced by changing the position of the road. In a few cases winding brooks have had straight channels dug to accomplish the same purpose. This is particularly the case in districts where the roads follow straight section lines without regard to topography.

The most elaborate investigation of surface and underground roadbed drainage that has been made in this country was undertaken by a committee of the American Railway Engineering Association, which reached the following conclusions:

Side ditches should be provided in cuts, whether the subgrade be in rock or earth. The minimum side ditch should be 1 foot wide on the bottom and 1 foot deep below subgrade. The minimum grade for side ditches should be 0.30 per cent If the rate of grade of the track in any cut is less than 0.30 per cent, the cut may be widened to permit side ditches to be constructed on 0.30 per cent grades, or drain pipes may be laid to proper grades below the ditches to any available outlet.

Efficient subdrainage of wet cuts and of saturated soil upon which embankments rest may be attained by the use of pipe drains. They should be laid immediately below the center of the side ditch in cuts and about 10 feet from the toe of the slopes of embankments and on grades of not less than 0.20 per cent. Care should be taken to locate the pipe at such depths that no displacement will be made in its alignment by the subsidence of the roadway under traffic. To this end the trench in which the tile is to be laid should be dug down into a motionless stratum underlying the saturated material which it is desired to drain. The trench above the pipe should be completely filled with cinders or other porous material which filters the water and aids its passage to the pipe and prevents the intrusion of the saturated material under pressure of traffic.

A water pocket beneath the track may be drained by small cross drains laid in cinder-filled trenches, or by trenches filled with cinders, gravel or similar material.

The committee recommended that no pipe be used with an inside diameter of less than 6 inches, except for cross drains. It will rarely be necessary to use larger sizes than 12 inches. The trench should not be wider than is needed for digging it economically and laying the pipe.

Surface intercepting ditches should be constructed on the uphill side of all cuts where they may be opened without causing slides. Open ditches should be dug along, and about 10 feet from, the toes of embankments resting on soil liable to become unstable if saturated, to divert water flowing toward the embankment. Where an open ditch may endanger such an embankment, a drain pipe may be laid along the toe of its slope. In constructing ditches on slopes above cuts, they should not be larger than necessary in order that they may not become the notch or score from which a slide will start. They should be 10 to 25 feet from the crest of the cut, and the material excavated from them should be deposited on the side nearer the roadbed.

Side Ditches

The cross-section of side ditches should be such that they can be formed and maintained by road machines, if practicable, for the use of such equipment in places for which it is suitable gives the desired results at lowest cost. The sections shown on page 226 illustrate the capabilities of road machines. In the final shaping of the road, care must be taken not to dig the ditches too deep at any place, leaving a depression to hold water. The purpose of a ditch is to carry water away without retaining any of it. If any depressions exist they must be remedied in some effective manner.

Very good results can be had by making side ditch 2 feet wide on the bottom with a 4:1 slope on the road side and a slope on the back side equal to the angle of repose of the particular material encountered in the excavation. The 4:1 slope on the road side is not dangerous to traffic, the slopes can be grassed with a good texture of grass and the slope is not so steep as to become gullied by water shed into the ditch from the surface of the road where the crown is excessive or the grade steep. The slopes can also be made and maintained with a road machine.

The grade of the flow-line of the ditch should be 0.5 per cent if possible, rather more than the recommendation for railway ditches previously quoted, but in flat country it is sometimes impracticable to secure such a grade. Under such conditions the grade lines for the ditches should be given by a surveyor, and the excavation made to conform exactly to the lines. When finished, these flat ditches must be maintained on the true grades, or water will fail to run off quickly. Flat ditches are often made wide and shallow, so as to expose as much water to evaporaton as possible, and on well-maintained level roads care is taken that these shallow ditches are not unduly shaded by trees and shrubs, so that evaporation will be checked.

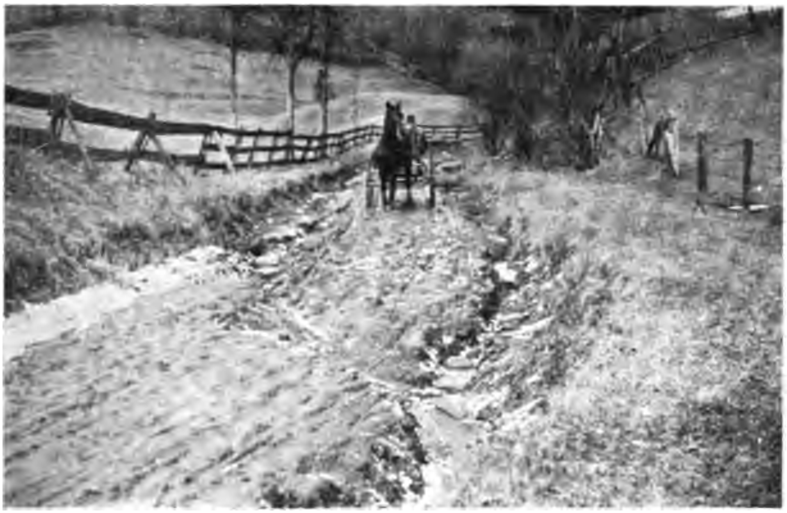
Where there are two convenient outlets with a side ditch running from one to the other, the grade may be improved and a deep, unsightly ditch avoided by selecting a good intermediate summit and drawing water both ways to the outlet. This summit may be regulated by the grades desired or by holding them from 6 to 12 inches below the sub-grade at the summit and running straight flow-line grades each way to the outlets.

Deep, narrow ditches with steep sides have two defects frequently observed where roads are not maintained properly. One defect is the danger they offer to vehicles which may be crowded into them for any reason. The records of the Iowa State highway commission for September, October and November, 1916, show that in that State alone 353 automobiles turned turtle, resulting in 5 deaths and 451 injuries. Just how many of these accidents were due to ditching the cars is not stated, but this is generally regarded as the usual cause of overturning. Where the ditches are deep or the road is on an embankment with steep slopes, substantial guard rails should be provided. During September, October and November, 1916, the Iowa records show that 167 cars went over embankments, killing 7 persons and injuring 234. Such a list points more clearly than general arguments to the great importance of guard rails that will act as real guards.

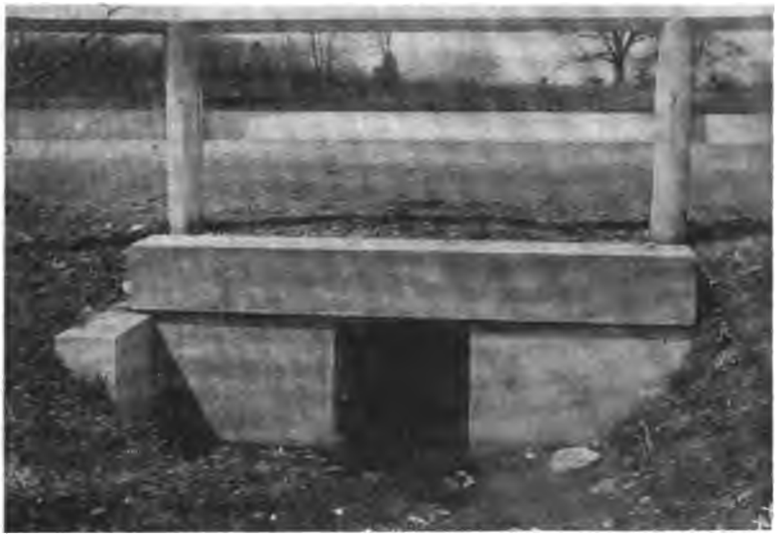
The second defect is the relatively high velocity which water may acquire in a deep, narrow ditch. If the latter is protected against erosion high velocity may cause no trouble, but such protection is not common and when the water rushes through an earth ditch the latter will become eroded and both the roadbed and the bank may be severely injured.

The maintenance of ditches cut in earth on slopes is hardly possible unless water-brakes are constructed in them. These are usually heavy timbers placed across the ditch and projecting several inches above it. They check the flow of the water at intervals down the hill, and thus prevent a velocity which will be destructive. The ditches where they are used must be cleaned out after every rain or the bottoms will become filled to the top of the timbers and later storms will gully the road and the banks at their ends. In some cases, the water-brakes are heavy concrete beams. Where the water attains an erosive velocity in ditches paving protects them better than the waterbrakes.

Wherever practicable ditches in earth on grades exceeding



Washout Due to Defective Drainage



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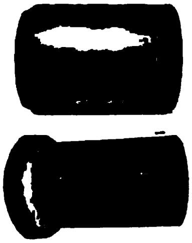

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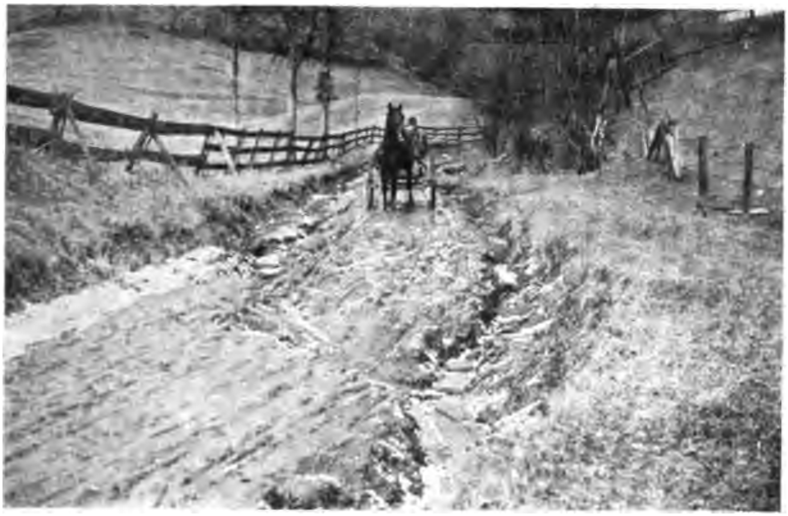
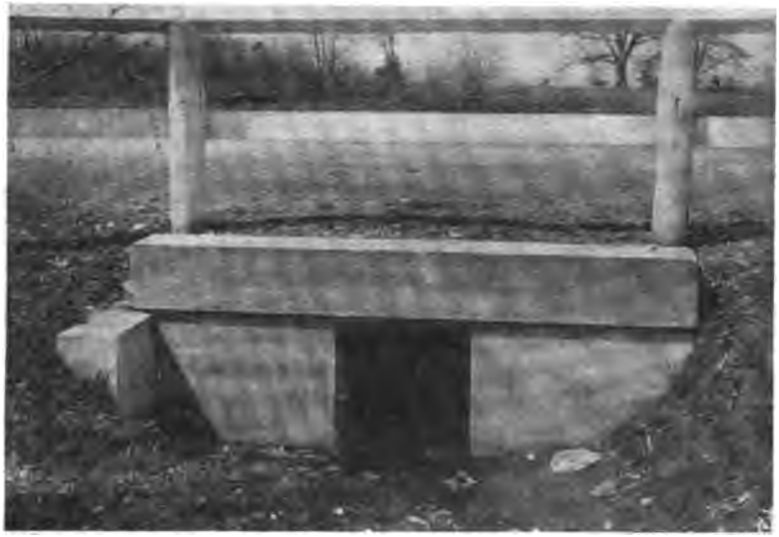


Washout Due to Defective Drainage



Head Wall of a Culvert on a Massachusetts Road

Underdrainage

The usual method of repairing a wet place adopted by an untrained roadbuilder is to dump stone over it. After the stone has been forced into the mud by the traffic, more stone is dumped there, with the result that a mudhole is formed at each end of the stone fill. The water is in the earth and must find an outlet somewhere. Instead of trying to seal it up, the proper remedy is to carry it off by some kind of underdrainage. The problem of caring for underground water is, first, a matter of soils; second, a matter of topography; and third, one of temperature. There are many soils of a gravelly, sandy, or similar character, which ordinarily are self-draining to a degree and do not require particular attention. The difficulty is with those highways built on clayey or loamy soils which are more or less retentive and do not drain readily.

When the entire roadbed is somewhat damp or soggy it was formerly the general practice to lay a foundation of large stones wedged together by small stones and thoroughly rammed. This is called a Telford foundation and is 6 inches or more thick. It is still used extensively for the purpose but there are substitutes for it which have come into use. In some cases from 6 to 12 inches of coarse gravel or small field stone are placed on the subgrade and rolled. Still another type of drainage foundation, developed first in Massachusetts, is formed by excavating the subgrade to a V-shape cross-section, 6 to 8 inches deep at the sides and 12 to 18 inches deep at the center, and filling this with field stones, the largest at the bottom. With any of these types, there should be an outlet every 50 feet or so from the lowest part of the foundation, formed by cutting a trench through the shoulders to the side ditches and backfilling it with coarse gravel or stone. Even when the road is not on wet land, many engineers build cross drains filled with stones at 50-foot intervals in the top of the subgrade of gravel and macadam roads. They are 5 or 6 inches deep at the center and are at right angles to the ditches except on hills, where they incline slightly downhill from the center.

In many parts of the country stone or gravel is unavailable for such drainage work and drain tile has been employed. It has proved successful and economical, even when stone could be obtained, provided it was laid properly. Many engineers recommend using drains whenever water remains in the ground for a considerable period of time within 3 feet of the surface. The reason for this is that the maintenance of a well-drained road is easier work than if the subgrade is soggy. If a heavy rainfall soaks the top of a road which is already soft below the surface, heavy loads are liable to rut it seriously, because it will take much longer to dry out than a well underdrained road. In the early spring, when the water in the ground freezes and thaws alternately, good underdrainage is particularly useful in preventing the upheaval of parts of the road.

The influence of a well-laid line of drain tile upon the position of the upper surface of the ground-water, called the "water table" by many engineers, is greater than many persons realize. Prof. Ira O. Baker has reported the following experimental proof of the extent of this influence. Lines of drain tile were laid 50 feet apart and 2½ feet deep in a field notoriously soggy and heavy on account of the presence of hardpan which held the water "like a jug." Where the field was without drainage the water rose to within 6 inches of the surface. Where it was drained, the water level midway between the drains was 18 inches below the surface, showing that even in such very heavy soil, the top surface of the ground-water 25 feet from the drain was only 1 foot above the tile. It is this wide influence of good drains which makes the effect of a single line of deep-laid tile along one side of a road greater than that of shallow lines along both sides. The general rule of agricultural drainage experts is to place drains 100 feet apart and at a depth of 3½ to 4 feet.

The drain is best laid in a trench below the ditch at the side of the road from which the greatest amount of ground-water is expected. Although a large number of drains laid perfectly horizontal for long distances have given satisfactory service, it is desirable to give them a uniform slope of at least 2 inches per 100 feet if possible. This is a somewhat lower minimum grade than some engineering books recommend, but is warranted by experience. The tile should not be smaller than 4-inch, and if the ground contains a large amount of water and the outlets of the drains are far apart, larger sizes may be desirable, particularly in level country.

Tile should not be laid except from grade lines given by the engineer, and they must be laid accurately to line and grade. The trench to receive them should be no larger than is necessary to lay them properly at the least expense, but in opening a trench it is sometimes less expensive to make it wider than required for the tile, because of the extra cost of digging in a very narrow trench. In any case the bottom should be cut very carefully so as to have it exactly on the right grade. If there is any probability that the bottom will settle and throw the tile out of alignment, a 4 by 1-inch plank is sometimes laid to support the tile. The ends of the tile are laid touching. Some engineers recommend covering the top half of the joint with tar paper or burlap, but this is probably unnecessary if the trench is backfilled with clean gravel or broken stone from 1 to 4 inches in size, which is the best material to use. In any case the filling should be porous and placed carefully so as not to move the tile. When the gravel or stone filling is within 12 inches of the surface, some engineers cover it with about 3 inches of hay or straw before the earth filling is placed to form the bottom of the side ditch.

The outlets of the drains should be constructed with special care, because they are particularly liable to injury. They are preferably made of stronger pipe than agricultural tile, firmly supported and protected at the end by a substantial wall or facing. A drain with its end stopped is of little value.

Pipe drains are the most serviceable type, but there are various substitutes. One of these is a covered trough of rough stone, another is a similar plank trough, and another is merely a mass of gravel and stones, with the largest pieces at the bottom. The drawback of all of these is that they tend to break down or become clogged with fine material, which can not enter a properly laid tile drain.

Where the side ditches are on very flat grades, they are sometimes drained into the underdrains at intervals of about 0.1 mile by blind catch-basins. These are merely masses of coarse gravel, stone or brickbats reaching from the bottom of the ditch to the tile, and covered at the top by a low pile of similar material which acts as a screen. By this means the side ditches need not be cut so deep as to be dangerous. Where the side ditches carry large quantities of water which must be drained off in this manner, large drain tiles are needed and open brick or concrete inlets like those used on sewerage systems may be used.

Where an embankment is built on a wet side hill, the latter must first be underdrained thoroughly to prevent slipping of the embankment. When an embankment in such a locality begins to slip, the trouble may sometimes be remedied by digging large, deep intercepting ditches on the high side, leading to the nearest culverts. These ditches are usually filled with stone. Any pockets in the ground near the uphill toe of the embankment, in which water may collect and soften the neighboring earth or clay, should be filled.

Size of Culvert Openings and Bridge Waterways

The waterway to be provided for large culverts and bridge openings depends upon many conditions, which have been stated as follows by Prof. A. N. Talbot:

1. The variation of the rainfall in different localities.
2. The meagreness of rainfall data, since records are generally given as so much per day and rarely per hour, while the duration of the severe storms is not recorded.
3. The melting of snow with a heavy rain.
4. The permeability of the surface of the ground, depending upon the kind of soil, condition of vegetation and cultivation, etc.
5. The degree of saturation of the ground and the amount of evaporation.
6. The character and inclination of the surface to the point where the water accumulates in the watercourse proper.
7. The inclination or slope of the watercourse to the point considered.
8. The shape of the area drained and the position of the feeders.

The importance of this item will be seen in comparing a spoon-shaped area where the main watercourse is fed by branches from both sides so arranged that water from the whole area reaches the culvert at the same time, with a long, narrow basin in which, before the water from the upper part reaches the opening, the rainfall from the lower portion has been carried away and the severe part of the storm is past.

While there are three formulas giving the size of waterways for drainage areas of different sizes, it is generally agreed by engineers that it is best to find out by examination and inquiry if possible the flood heights of any stream that is crossed. The condition of neighboring culverts and bridge openings during floods should be investigated, and the nature of the channel of the stream and the character of its drainage basin ascertained. Such records are not only helpful in determining the size of the structure under consideration but are of value in showing the degree of reliance that can be placed on a waterway formula.

A formula widely used in the Central States was proposed in 1887 by Prof. A. N. Talbot. The area in square feet of the net waterway is found by multiplying the three-fourths power of the acres drained by a coefficient. This coefficient was taken by Professor Talbot as 0.33 for rolling farming land subject to floods when snow melts and the valley drained is three or four times as long as it is wide, 0.16 to 0.2 in districts not affected by snow and with the valleys several times longer than wide, and from 0.67 to 1.0 for steep, rocky ground. The waterways given by this formula are stated in the table on the next page.

Square Feet of Waterway Required by Talbot's Formula for Passing the Runoff from Areas Stated of Different Classes of Land

ACRES DRAINED	LEVEL LAND	ROLLING LAND	HILLY LAND	MOUNTAINOUS	ACRES DRAINED	LEVEL LAND	ROLLING LAND	HILLY LAND	MOUNTAINOUS
10	1.1	2.3	3.4	4.5	180	9.8	19.7	29.5	39.3
20	1.9	3.8	5.7	7.6	200	10.6	21.2	31.8	42.5
30	2.6	5.1	7.7	10.2	240	12.2	24.4	36.6	48.8
40	3.2	6.4	9.5	12.7	280	13.7	27.4	46.1	54.8
50	3.8	7.5	11.3	15.0	320	15.1	30.3	45.4	60.5
60	4.3	8.6	12.9	17.2	360	16.5	33.1	49.6	66.1
70	4.8	9.7	14.5	19.4	400	17.9	35.8	53.7	71.6
80	5.4	10.7	16.1	21.4	440	19.2	38.4	57.6	76.9
90	5.8	11.7	17.5	23.4	480	20.6	41.2	61.8	82.3
100	6.3	12.6	19.0	25.3	520	21.8	43.6	65.3	87.1
120	7.3	14.5	21.8	29.0	560	23.0	46.0	69.1	92.1
140	8.1	16.3	24.4	32.6	600	24.2	48.5	72.7	97.0
160	9.0	18.0	27.1	36.1	640	25.4	50.9	76.3	101.8

About 1880 the Santa Fe system began to measure accurately the area of the waterways of streams during floods in Missouri, Kansas, Indian Territory and Texas. The work was done as carefully as possible and in 1897 the results were summarized and a table of waterway areas issued by James Dun, chief engineer of the system, for the use of his engineers. The collecting of such information was continued after that date, and in 1906 an enlarged table was printed for public use, which is extensively employed by railway and highway engineers in the section of the

Square Feet of Waterway Given by Dun's Table for Passing the Runoff from Areas Stated; Applicable to Missouri and Kansas

Area, square mile	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
Waterway, square feet	2.0	4.0	6.0	7.5	9.0	10.5	12.0	13.5	15
Area, square mile	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50
Waterway, square feet	16	25	32	38	44	51	56	62	66
Area, square mile	0.55	0.60	0.65	0.70	0.75	0.80	0.85	0.90	0.95
Waterway, square feet	70	74	78	81	85	88	91	94	97
Area, square mile	1.0	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8
Waterway, square feet	100	110	120	130	140	150	160	170	180
Area, square mile	1.9	2.0	2.2	2.4	2.6	2.8	3.0	3.2	3.4
Waterway, square feet	190	200	220	240	260	280	300	321	340
Area, square mile	3.6	3.8	4.0	4.2	4.4	4.6	4.8	5.0	5.5
Waterway, square feet	357	373	388	403	417	430	443	455	483
Area, square mile	6.0	6.5	7.0	7.5	8.0	8.5	9.0	9.5	10.0
Waterway, square feet	509	533	556	579	601	622	641	660	679

country mentioned. A portion of the table is reproduced here. Mr. Dun stated that it did not give waterways large enough for the floods that occurred at very long intervals and were of unprecedented severity, for which he did not consider it advisable for provision to be made. He recommended waterways 60 to 80 per cent as large as those tabulated for culverts and bridge openings in Illinois, about 5 per cent larger waterways for Texas when the areas drained exceeded 1 square mile, and from 1½ to 6½ per cent smaller waterways in New Mexico for areas exceeding 1 square mile.

About thirty years ago, C. C. Wentworth, of the engineering staff of the Norfolk & Western Railway, made a careful study of the area of the culverts which had proved of sufficient size on that road, and found that for drainage basins of one acre and upward, the square feet of culvert cross-section should be equal to the two-thirds power of the number of acres drained. This formula has been used for many years on that railway and found entirely satisfactory. The accompanying table gives the areas computed by it for a number of drainage districts. These relations hold good quite generally over the area between the Blue Ridge and the Ohio River, and have been found to agree with flood discharges in Maine, Connecticut, and New York. It has been suggested that with rainfalls of less intensity or flatter slopes than those of the section which furnishes the data on which the formula is based, the areas of necessary waterways may be taken at some percentage of those given by the formula.

Square Feet of Waterway Required to Discharge the Runoff from Areas of 1 to 99 Acres, Computed by the Wentworth Formula

	0	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0
0	......	1.0	1.6	2.1	2.5	2.9	3.3	3.7	4.0	4.3
10	4.6	4.9	5.2	5.5	5.8	6.1	6.3	6.6	6.9	7.1
20	7.4	7.6	7.9	8.1	8.3	8.5	8.8	9.0	9.2	9.4
30	9.7	9.9	10.1	10.3	10.5	10.7	10.9	11.1	11.3	11.5
40	11.7	11.9	12.1	12.3	12.5	12.7	12.8	13.0	13.2	13.4
50	13.6	13.8	13.9	14.1	14.3	14.5	14.6	14.8	15.0	15.1
60	15.3	15.5	15.7	15.8	16.0	16.2	16.3	16.5	16.7	16.8
70	17.0	17.2	17.3	17.4	17.6	17.8	18.0	18.1	18.3	18.4
80	18.6	18.7	18.9	19.0	19.2	19.3	19.4	19.6	19.8	19.9
90	20.1	20.2	20.4	20.5	20.7	20.8	21.0	21.1	21.3	21.4

Culverts

As the amount of water to be carried across the roadway by a culvert is usually small, the majority of such structures are made of some kind of pipe. The defects which such culverts develop at times are generally due to lack of attention to features essential for good construction. The pipe must be laid on a perfectly firm support. If the trench for it is cut too low and must be leveled by replacing some of the material, the latter should be consolidated thoroughly before the pipe is laid, and as it takes considerable time to do this properly, it pays to be careful to excavate in the first place to the exact grade.[1] After the pipe has been laid and the joints filled if it is made of bell-and-spigot lengths, the backfilling should be done with the same care used in good sewerage work. The earth should be rammed thoroughly around the sides of the pipe, taking care not to disturb it in doing this, and not more than 6 inches of earth should be spread without ramming. The 2 feet of fill immediately over the pipe should be similarly placed in 6-inch layers and rammed, and while the material above this need not be placed so carefully it should be thoroughly consolidated.

The inlet and outlet of the pipe should be at the bottom of the ditches it connects or at the level of the bed of the brook that it carries across the road. Each end should have a wall or facing resting on an absolutely firm foundation far enough below the surface to remain unaffected by frost and heavy enough to hold back the bank resting against it. Concrete makes the best facing, but substantial masonry and heavy planks have given good service when properly used. By locating and protecting the ends of the pipe in this way two important advantages are gained, first, the thorough drainage of the side ditches and, second, the prevention of undercutting of the ends of the pipe. If the bottom of the ditch or bed of the brook is soft, it should be paved for some feet above and below the culvert to prevent serious erosion during severe storms. At irregular intervals several years apart the ditches and brooks are exceptionally flooded and the water is liable to rise above the top of the pipe. If the culvert has been constructed as just recommended no danger need be feared, for the road will act as a dam for a few hours until these excessive quantities of water are discharged. A poorly built culvert is likely to be washed out, however, and carry part of the road with it. Standard plans for culvert headwalls can be obtained from most State highway departments and from the United States Office of Public Roads and Rural Engineering at Washington.

Where a pipe culvert is carried across a side-hill road, discharging on the outer slope, some form of channel is often necessary for carrying the water down the side of the embankment without causing erosion. Gutters of rough stone paving, concrete channels and metal troughs have all been used for this purpose.

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[1] If the sub-grade is soggy it is well to lay the pipe on a concrete floor running from the foundation of one headwall to that of the other. Bell joints should be laid up-hill.

When a culvert is formed of two pipes laid side by side, which is desirable where the grades are very flat, or the bed of the brook is wide and the depth of water shallow even after heavy rains, particular care must be exercised in consolidating the filling between the pipes.

In a few places, where timber is abundant and cheap, culverts of heavy plank are used, but at the best, they are only temporary structures, and it is unwise to put temporary works which are costly to replace in a roadway graded to permanent lines. The same is true of box culverts of dry masonry, with unpaved bottoms. Masonry culverts laid carefully in cement mortar are rarely so cheap as permanent pipe or concrete culverts. Plans and instructions for building concrete culverts can be obtained on application from most State highway departments and from the United States Office of Public Roads and Rural Engineering.

Any type of concrete culvert should be built carefully or frost will cause trouble with it. The sand and gravel or broken stone must be clean and graded so as to give a dense mixture, and the mixing of the mortar must be thorough. The forms must be strong and tight and located so that the structure will be true to grade. The headwalls in particular should be carried down to a secure foundation, and piling or a substantial timber platform should be used to carry the concrete in case there is any doubt whatever of the supporting power of the underlying material.

The general tendency of rapidly flowing streams is to lower their beds. This results in time in leaving the culvert floor rather high for the natural bed of the stream and the water finds its way underneath. A substantial cross wall at the outlet end of the culvert, carried well below possible wash, is effective in stopping this class of under-cutting, A frozen earth floor will sometimes act like a plank floor in causing such undercutting, and hence good cross-walls are advisable in all culverts, whether floored or not. If the channels leading to or from a culvert are in soft material liable to erosion, they should be paved or protected by brush and heavy stones.

Bridges

Structures with a clear span exceeding 6 feet are generally classed as bridges and should be permanent improvements on any road brought to final grade and alignment. There has been such great waste of money in past years on the bridges on rural roads that the highway departments of most states have prepared standard plans and specifications which cover most needs of local road officials, and similar standards have been prepared by the United States Office of Public Roads and Rural Engineering. Structures of this character should only be built under competent engineering supervision, both as to substructures and superstructures. There is an unfortunate tendency on the part of highway commissions to endeavor to save money by omitting desirable precautions such as piling, which insure the safety of the bridges under conditions which an engineer recognizes as dangerous. For example, an unusually heavy rainfall in northeastern Iowa in June, 1916, washed out 163 bridges. Some were old structures that needed replacing at an early date, but others were expensive new structures of good design and construction except for the fatal omission of the piling under the foundations which was recommended by the engineers but left out to reduce the cost. Not a bridge built according to the standards of the State highway commission was damaged.

There are many bridges which have been in service for a long period of time without suffering any injury, although their substructures are in streams with an easily eroded bottom and banks. For example, the Walhouding aqueduct on the Ohio canal system, built about 1830, has four piers and two abutments in a stream with a fairly swift current, rising suddenly to a great height. Both its banks and bed near the aqueduct are rapidly eroded unless protected. The piers and abutments rest on double platforms of hewn timbers, laid crosswise and carried by piles driven close together near all four sides of each base. Brush and heavy stone were placed on the river bed around each foundation and a row of strong piles was driven across the river bed just below the aqueduct to prevent the removal of the brush and stones by the current. Such a record of endurance made by structures built before the beginning of the present era of scientific engineering shows how needless are most of the washouts of expensive bridges that occur every year.

As bridges on improved roads should be permanent structures, they should be designed to carry a heavy roller followed by a trailer loaded with coal. A bridge capable of supporting a 15-ton roller will carry any of the heaviest field guns now used in Europe.

Money is saved by having the plans and specifications for bridges of reinforced concrete or steel prepared by an experienced engineer, so that all bidders on its construction will base their estimates on the same structure and that structure will be adapted to the locality and service. If each bidder must prepare

CHAMPION BRIDGE COMPANY
Steel Highway Bridges
WILMINGTON, OHIO
ATLANTA, GA.

VINCENNES BRIDGE COMPANY
Structural Steelwork
Memphis, Tenn. Vincennes, Ind.
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RIVERSIDE BRIDGE COMPANY
Steel Structures
MARTINS FERRY, OHIO

Minneapolis Steel & Machinery Co.
STEEL BRIDGES FOR THE WEST
Minneapolis, Denver
Salt Lake City Helena Spokane

THE MOUNT VERNON BRIDGE CO.
Steel Highway Bridges
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his own plans, the expense of doing so is added to the cost of the fabrication of the steel and the erection of the structure. This makes a general increase in the cost of bridges in a district where the practice is followed, for many unsatisfactory plans must be prepared for one that is satisfactory. Furthermore the commission awarding the contract must not only pick out the lowest bidder but also decide which is the best plan, which may not be that offered at the lowest price.

In level country where a stream overflows its banks during heavy floods and bridges above the flood level require long expensive approaches, what are known as overflow bridges are coming into quite extensive use. They are structures designed to be submerged by the floods and to offer as little obstruction as possible to the water passing over them. If the floods are likely to carry large quantities of brush, the bridges are kept particularly low so the brush will pass freely over them when they are submerged. The roads leading to a number of such bridges have concrete pavements extending to the limits of the submerged areas, for earth, gravel and broken stone roads are liable to serious injury from water flowing across them. As the injury to overflowed embankments generally starts at the top of the downstream slope, the latter is often protected against scouring by covering it with heavy stone. Stone with rounded edges is less suitable for this purpose than stone of an angular shape, because the former is rolled about more easily.

Fords

Where money is limited, the cost of building even a submerged bridge is heavy, and the stream to be crossed is shallow, a ford is sometimes constructed as a serviceable temporary expedient. In Washington County, Utah, for example, there is a stream with a sandy bottom which is dry at some seasons and dangerous during floods on account of the treacherous nature of the wet sand. A ford has been constructed which consists of two rubble walls 4 feet deep and 2 feet wide, with a 2-foot rubble fill between them. The entire width of this rubble fill from one wall to the other is 20 feet, and the stones of which it is made were laid in a dense mixture of sand and clay, which is not easily washed out of the voids between the stones. The upstream wall was laid dry but had 16 inches of clay puddled against the entire depth of its outer face. The downstream wall was laid in lime mortar.

Near Shelbyville, Tennessee, fords have been made passable at all times by constructing a number of parallel culverts close together to carry the usual flow of the stream and building a concrete roadway over these culverts to give a safe footing for horses and a secure roadway for automobiles during high-water when the roadway is submerged.

EARTH AND SAND-CLAY ROADS[1]

As a very large proportion of our country roads must be earth roads for many years and the basis for any type of surfaced highway is a properly located, drained and graded earth road, the relative importance of this type is very great. If earth roads were properly constructed and maintained, and their culverts and bridges were permanent structures, a large part of the road taxes now wasted would produce useful returns. It is proper for both highway commissions and engineers to devote a large part of their time and money to the improvement of the main roads which are of service to the largest number of taxpayers, but there is a deplorable lack of efficiency in the care of the local dirt roads in many parts of the country. In some States, of which New York, Illinois and Iowa are examples, these roads are under some supervision, directly or indirectly, by the State highway department, but generally the local authorities do as they please. For instance, in 1916 there were 71,000 miles of roads in Wisconsin in sole charge of local officials, who spent about $4,500,000 on them. The work was subdivided among nearly 13,000 road districts, each with a road supervisor, and there were 3750 members of town boards with general control over road work. Of these 16,750 officials, about one-fifth drop out of office annually. During the ten years ending December 31, 1916, nearly 50,000 men were in charge of local road work and over $40,000,000 spent by them, with few perceptible lasting improvements. A system giving such results is manifestly wrong, and should be replaced by one with a smaller number of road officials having greater authority and responsibilities and serving longer terms. It will seem from the following notes that the construction and maintenance of earth roads calls for executive ability and skill that cannot be obtained unless fair permanence in office is assured.

The construction of earth roads falls into two general classes, that where there are cuts and fills and that where the road is formed by building a low embankment on the surface. Except where the length of road is great enough to use elevating graders with economy, these two classes are generally built by different methods.

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[1] Revised by W. S. Keller, State Highway Engineer of Alabama.

Cuts and Fills

In grubbing roots and breaking hard ground to a shallow depth, a rooter plow is often used, which is a heavy type of subsoil plow made for the purpose. The road plow is a heavy form of turning plow used in hard ground where the cuts are shallow. Either type is drawn by four to eight horses or a tractor. Plows are also specially made for pushing soil already loosened from ditches toward the center of the road.

When the cut is more than a few feet in depth and the material loosened with difficulty, it is often blasted. The fastest and most economical method of doing this is to sink holes across the cut on a line back from the face a distance about one-fourth greater than the depth of the cut and about the same distance apart. When the cut is 6 feet or more deep, the line of holes is kept about 6 feet from the face and the holes are sunk about 6 feet apart. They are loaded with a low-strength explosive and care must be taken not to loosen the ground below the finished grade line. The use of explosives in road grading in other material than rock has been extending rapidly on account of its low cost and the rapid progress that can be made under suitable conditions, for the blasts leave the clay or hardpan in a broken up condition making it easy to handle. On side-hill cuts in heavy ground, where the slope is steep and there is some question about the security of an embankment to carry the outer part of the road, a safe roadway can often be blasted out of the hill at a cost comparing favorably with a road partly supported by a retaining wall. Even on easier slopes, where a long side-hill cut in heavy ground must be made and the excavated material can be employed as an embankment to carry the outer part of the roadway, the excavation is often made by blasting. Blasting is also an effective method of breaking up stumps and boulders.

Where the material is easily handled and can be dumped within 100 feet of the cut, slip scrapers are generally regarded as the least expensive equipment. The Fresno scraper is regarded as better than the slip scraper for hauls exceeding 100 feet. If the haul exceeds 100 feet and is under 1000 feet, wheel scrapers are ranked highly. The large sizes are most desirable for economy on hauls over 600 feet. The material is usually plowed so the wheelers can be loaded easily, and it is necessary to have about one of them for every 100 feet of haul in order to work most economically. Bottom-dump wagons can be made to give very low hauling costs if enough are provided so that while one is being loaded at the cut, the driver and team which brought it in can be used in hauling a loaded wagon.

In recent years traction steam shovels have been growing steadily in favor for road grading. They make shallow cuts as easily as deep cuts, and have taken out earth and rock at very low figures when the equipment for removing the excavated material was properly selected and used so as to keep the shovel working most of the time. The economy of steam shovel operation depends upon the proportion of the working day that it is actually digging, and this depends upon having wagons or cars ready to receive the excavated material. The wagons or cars may often be run along the top of the bank of a shallow cut and kept moving in a continuous line, saving the delay of turning and backing up to the shovel, which is necessary when they move over the graded cut. The utility of a shovel on roadwork is increased if it can be employed in a gravel pit or quarry when not grading.

The bottom of the cut should be carried down approximately parallel to the finished cross-section, and care should be taken not to disturb the material below the grade line. In very heavy ground, the final trimming is sometimes done by hand, but generally a road machine can be used to advantage.

Where a fill is made, the surface must be cleared. Stumps should be grubbed out[1] and all large material liable to decay should be removed, for if left in place the fill will settle as it rots or have loose places likely to retain moisture. If the fill is on a steep side-hill, the latter should be cut into a series of level benches or steps and the drainage should receive careful attention. If the hill has a gentle slope, it is usually sufficient to plow parallel furrows, which will furnish a sufficiently uneven surface to hold the fill. The object in any case is to unite the material in the bottom of the embankment with that of the hillside.

If the road will be maintained as an earth road for several years, so it will have ample time to become consolidated under traffic before any surfacing is applied, there is usually little reason for limiting the thickness of the layers in which the embankment is built. But if a surfacing is to be given the road at an early date, the layers should not exceed 2 feet for high fills and 1 foot for low fills. The teams and scrapers moving over the fill compact it to some extent. Formerly little attention was paid to smoothing the surface of the layers, but of late this has been considered important in some states and drags are kept at work on a bank a large part of the time. George W. Cooley, State engineer of Minnesota, has explained this leveling work as follows:

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[1] It is not customary in the South to require green stumps and roots to be grubbed where the fill over their tops is as much as 18 inches. Any matter in process of decay must be removed but a green stump sealed in a fill so that air will not reach it lasts forever.

In Minnesota the plan has been adopted in the construction of earth roads to require the continual use of a drag or planer on grade building. This latter plan has been found very efficient and renders future work on the surface less expensive, besides tending to produce a more compact road bed. The tool found most satisfactory in this work is that known as the "Minnesota road plane," which consists of the two blades of an ordinary road drag, fixed between a pair of runners about 14 feet long, the blades set at an angle of about 60 degrees to the runner and made rigid or adjustable as may be deemed best. The planer is hauled on a line parallel with the axis of the road and its operation is similar to that of the ordinary drag, with the additional advantage of making a smoother surface. The old style drag without runners has a tendency, especially on new work, to increase the waves or undulations frequently occurring on road construction, while the planer eliminates these faults and as a general maintenance tool has proved the most satisfactory.

All embankments settle or "shrink" for some time after they have been built. If the material is broken into small pieces and trampled by teams, the shrinkage will be less than if it is dumped in large masses. There is little shrinkage in a well-built earth dam to impound water, but road embankments need not be built so carefully, and it is probably desirable to allow for at least 10 per cent shrinkage of embankments over 3 feet high and at least 15 per cent for those under 3 feet. If loamy material is used in the embankments the shrinkage will probably be greater than this.

Grader Work

A large part of the earth roads now built or reconstructed are made with road machines. These are built in many sizes for both horse and tractor hauling, and serve a variety of purposes in an economical manner. They are not adapted for making cuts and fills, although frequently employed in shaping a road after the grading has been done. The method of using the machine on construction is explained in the following instructions prepared by W. S. Gearhart, State engineer of Kansas:

In building new roads with a road grader the dead weeds and grass should first be burned off before any grading work is done, and the width of the road to be graded should be staked so the ditches can be properly lined up. Then plow a light furrow with the point of the grader blade, carrying the rear end of the blade well elevated.[1] On the second round drive the wheels in line with the point along the hollow made the first round, plowing a full furrow with the advance end of the blade, dropping the rear end somewhat lower than before. The third time move toward the middle of the road the earth previously plowed, then return to the ditch and plow it out deeper, moving the earth toward the middle whenever as much has been plowed as the machine will move at once. Repeat this process until the ditches are the proper depth, and then cut off the outer slopes of the ditches by placing one wheel of the grader in the bottom of the ditch and the other one on the bank. This can be done easily if the bank is not more than 30 inches above the bottom of the ditch. Then trim the earth to the true cross-section. Thoroughly harrow the loose material with an ordinary straight-tooth harrow if there are no clods, going over it until the bumps have been leveled off, the low places filled up and the material well compacted. If there are sods or tough lumps of earth in the road a disk harrow should be used to pulverize this material, and the disk harrow should be followed by a drag or a straight-tooth harrow to level and smooth the road. No newly graded road can be finished in good shape without using either the harrow or the drag, or both.

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[1] A plow is necessary in breaking up the ground except in light soils.

In the later rounds of a road machine, in the final shaping of the road, part of the loose material in the center of the road is pushed back to the shoulders. The settlement on fills will result in losing about 2 feet in the width of the roadway, and the fills should be made wider than the standard sections to allow for this loss. In doing this final work, the blade of the grader is set at an angle of about 45 degrees with the direction of travel, its ends adjusted to the slope of the road, and lowered as a whole on successive rounds.

If the work is on a scale large enough to warrant the use of two graders hauled by a tractor or roller, a trained grading crew is often able to build a good roadbed at very low cost. Mechanical traction has resulted in the development of methods of construction impracticable when teams of four to eight horses were employed, and as a general proposition mechanical traction is most economical when the sections to be graded are a quarter of a mile or more long, and there is enough work in the vicinity to keep a tractor busy most of the time.[1] Time lost in standing idle or moving long distances from one grading job to another reduces the economical advantage of a tractor on work not well organized. In many cases the hauling is done by a road roller. Tractors and rollers are particularly good investments where labor and teams are hired at high rates and not always obtainable. Mechanical traction is so much more powerful and rapid than horse traction, that its total saving on road work can only be figured by including the saving in labor charges due to speedy construction.

Where road grading is carried on by day labor by district officials, preparation is sometimes made for it in late fall or early spring by plowing up the ground along the lines of the ditches and slopes. This disintegrates the sod and prevents the roots of grass and weeds from forming clods which must be broken up by disk harrows or thrown out of the road with forks. While it is allowable to build an embankment on good sod after it has been burned over, neither sod nor any other organic material should be allowed in the embankment unless reduced to small, disconnected bits. If clods are left in a fill, particularly in the top, it is very difficult to maintain by dragging a hard, uniform surface free from depressions and waves.

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[1] Traction grading with heavy road machines is better adapted for some conditions than others, and the advice of an experienced engineer should be obtained before purchasing expensive equipment.

Grading by machines is often followed up immediately by hand trimming and the removal of loose stone. Easing upon work by leaving steep, untrimmed slopes and uneven ditches results in heavier maintenance expense.

In organizing grader work, it is desirable to keep on hand repair parts of the machines, such as blades and whiffletrees, as well as plow points and other parts of the equipment likely to wear out. The small tools should be selected with care, for observation by efficiency specialists has shown that the shape of a shovel, for example, has considerable effect on the amount of shoveling a man can accomplish in a day. Hard earth cannot be dug economically by the shovel best adapted for loose earth, and neither is best for gravel and broken stone.

On extensive work the elevating grader has proved an economical and rapid machine when a mile or more of road can be traversed without turning the outfit. Such a grader is often hauled by a traction engine, which rolls the material it passes over and thus assists materially in making a compact road. The method of using the grader depends upon the nature of the work to be done. In cuts, the grader often discharges the excavated material into wagons driven beside it until full. These wagons haul the material to the nearest fills. In light cuts, the material is deposited on the roadway and moved to the nearest low places in the road by slip or wheel scrapers. The cut is usually started at the shoulder and the grader moves toward the roadside on successive rounds, so that the excavated material is deposited nearer and nearer to the center of the road by the elevating and discharging device. The road should be dragged during construction, and as soon as the rough grading is finished it should be shaped at once. In this connection attention is called to the following comment by the Iowa highway commission:

> The impassable condition to which some contractors and county road crews reduce their roads while cuts, fills and other improvements are being carried out, is absolutely inexcusable. The worst conditions usually arise at leveling or smoothing up while dumping is in progress. The dirt of the fill so dumped packs in humps so that sometimes it is impracticable to eradicate the unevenness for years. A little care in spreading the dirt evenly at the time of dumping results in the fill packing in thin, even layers instead of humps. Such a road is travelable during construction, and when the fill is completed the job is done. A Marshall County road crew solved the problem by keeping a light road drag at hand. From time to time a team was unhooked from a scraper and hitched to this. A few minutes work put the freshly dumped material into thin layers instead of humps.

The utility of a road roller on earth roads is generally underestimated. After the earth has been given as much crown as the road can have and still enable the traffic to use its entire surface readily, any further improvement of the surface drainage must be attained by decreasing the porosity of the earth. This can be done by oiling the road as described later in the section on Surface Applications, and by reducing the pores of the earth by rolling. The latter is particularly useful in compacting places of a yielding character. Many counties have purchased rollers, placed them in charge of competent men, and rent the outfits to the townships as the latter need them. In some cases, a roller is bought by a number of townships, acting as a whole. The work of a roller outfit is likely to be unnecessarily expensive if it is not carefully planned so as to avoid long journeys to do small jobs.

Dragging

Earth roads under light traffic can be kept in good condition during a large part of the year by dragging and proper care of the ditches. It is an axiom in road maintenance that defects in the surface of a road should be remedied as soon as they appear, because traffic will develop them quickly. The earth road is particularly subject to injury because it does not have hard stone locked in place to resist the destructive effect of horses' shoes, narrow tires and pneumatic tires. On the other hand it is more easily repaired than any other road, because as soon as its surface is wet by rain the ruts and holes can be filled by hauling a drag over the surface. This scrapes material from the high points into the depressions and rubs down the whole surface. The following explanation of the nature of the improvement has been given by A. R. Hirst, State highway engineer of Wisconsin:

> If a sample of moist earth is taken from the traveled portion of a road over a gumbo, clay or black prairie soil, it will be found practically impervious to water, as may be proved by forming a roughly shaped dish of damp earth and filling it with water. It will be noticed that the dish is practically water-tight. Earth in this condition is what the clay workers call puddled. It has been worked and reworked by the carriage wheels and animals' hoofs until nearly all the traveled portion of a sticky muddy road is covered with a layer of this impervious, puddled earth. As usually found on most of the roads, this puddled earth is full of holes and ruts, which are filled with water that cannot escape through the impervious soil. As long as the water remains the soil cannot dry out and the road is kept in a most uncomfortable if not impassable condition. It is also a matter of observation that this puddled earth when compressed and dried becomes extremely hard. On these two facts, the imperviousness of puddled earth and its hardness when dried, rests the theory of road dragging.

When the road drag is properly used it spreads out the layer of impervious soil over the surface of the road, filling up the ruts and hollows until a smooth surface is secured. As a small amount of material is always to be pushed to the center, a slightly rounded effect will be given to the road, which may be increased or decreased as desired by subsequent dragging. By forcing the mud into the hollows and ruts it is evident that the water must go out, which it does by running off to the side of the road. The drying out of the road is thus much facilitated and the road is made immediately firmer because the water is squeezed out. The effect of traffic over the road tends to press down and thoroughly compact each thin layer of puddled earth which the drag spreads over the surface every time it is used. After the first few draggings it will be noticed that the road is becoming constantly smoother and harder so that the effect of a rain is scarcely noticeable, the water running off the surface which is so smooth and hard as to absorb but little of it.

The drag is an old implement. It was described in a book by William Gillespie published in 1851 and widely used by students of engineering and public officials, yet the drag did not come into favor until about 1900. Even today it is not used on more than a small percentage of the roads where it should be employed regularly. It has a number of forms, the essential feature being two parallel blades held vertically or nearly so about 2½ feet apart by a frame of some sort. The bottom of each blade scrapes over the surface of the road. The rear blade projects 12 to 16 inches to one side of the front blade so that when the drag is pulled at an angle of 30 degrees, the ends of the blades will be on a line parallel with the center of the road. The drag is hauled by a chain, to which the team can be hitched at points that will make the drag lie diagonally on the road as it is pulled along. The manner of its use has been described substantially as follows by the United States Office of Public Roads.

Under ordinary circumstances the position of the hitching link on the draw chain should be such that the runners will make an angle of from 60 degrees to 75 degrees with the center line of the road, or in other words, a skew angle of from 15 degrees to 30 degrees. It is apparent that by shifting the position of the hitching link the angle of skew may be increased or diminished as the conditions require. When dragging immediately over ruts or down the center of the road after the sides have been dragged, it is usually preferable to have the hitching link at the center of the chain and to run the drag without skew. When the principal purpose of the dragging is to increase the crown of the road, the drag should be sufficiently skewed to discharge all material as rapidly as it is collected on the runners. On the other hand, if depressions occur in the road surface, the skew may perhaps be advantageously reduced to a minimum, thus enabling the operator to deposit the material which collects in front of the runners at such points as he desires by lifting or otherwise manipulating the drag. It is impracticable to prescribe even an approximate rule for fixing the length of hitch, because it is materially affected by the height of the team and the arrangement of the harness, as well as by the condition of the road surface. Experience will soon teach the operator, however, when to shorten the hitch in order to lessen the amount of cutting done by the front runner and when to lengthen it in order to produce the opposite effect. Care should be taken that a ridge, often called a "potato ridge," is not left in the center of the road.

When the road surface is sufficiently hard or the amount of material which it is desired to have the drag move is sufficient to warrant the operator standing upon the drag while it is in operation, he can greatly facilitate its work by shifting his weight at proper times. For example, if it is desired to have the drag discharge more rapidly, the operator should move toward the discharge end of the runners. This will cause the ditch end of the runners to swing forward and thus increase the skew angle of the drag. The operator may, of course, produce the opposite effect by moving his weight in the opposite direction. In the same way, he can partially control the amount of cutting which the drag does by shifting his weight backward or forward, as the case may be.

The rule frequently cited, that all earth roads should be dragged immediately after every rain, is in many cases entirely impracticable and is also very misleading because of the conditions which it fails to contemplate. It is true that there are many road surfaces composed of earth or earthy material which do not become very muddy under traffic, even during long rainy seasons, and since such surfaces usually tend to harden very rapidly as soon as the weather clears up, it may be desirable to drag roads of this kind immediately after a rain. Such roads, however, would not ordinarily need to be dragged after every rain, because of the strong tendency that they naturally possess of holding their shape. On the other hand, many varieties of clay and soil tend to become very muddy under only light traffic after very moderate rains, and it is evident that roads constructed of such materials could not always be successfully dragged immediately after a rain. Sometimes, in fact, it may be necessary to wait until several consecutive clear days have elapsed after a long rainy spell before the road is sufficiently dried out to keep ruts from forming almost as rapidly as they can be filled by dragging. In many cases of this kind, however, it is possible greatly to improve the power of the road to resist the destructive action of traffic during rainy seasons by repeatedly dragging it at the proper time.

Maintenance by dragging is most successful when well organized. The results obtained by good management in Hopkins County, Kentucky, are frequently cited as indications of this, and for this reason the following account of the work there is quoted from a report by the Kentucky department of highways.

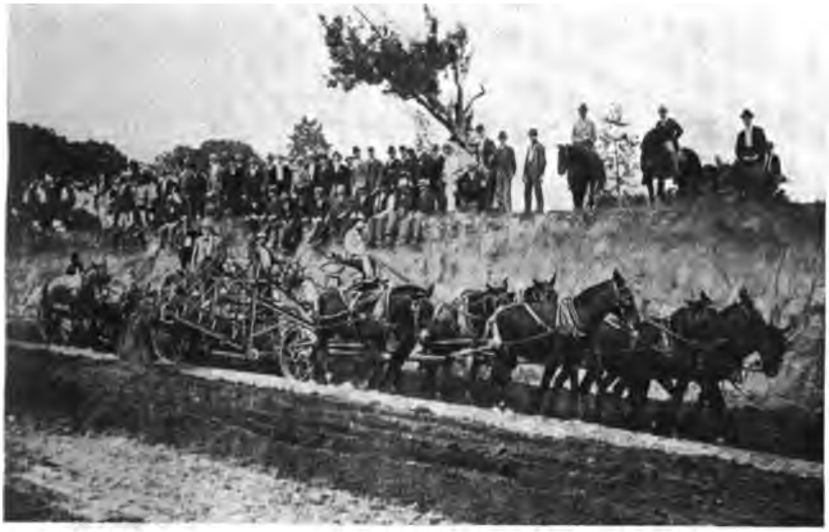
> In 1912 a county engineer was appointed. The county roads were measured under his supervision and 2-mile sections designated, and in January, 1913, drags were started on about 100 miles of the county roads. This original contract was only for dragging the roads, which work was to be done four times between January 1 and April 1, at a cost of $10 to $12 per mile. As the sections dragged were not continuous, the citizens

at once appreciated the difference between the maintained road and that which was not maintained. Consequently the next contract, which called for dragging and also for cleaning the ditches for six months, until November, 1913, resulted in contracts for 150 miles of road and at a reduced cost. In November, 1913, a contract substantially like that now in use was adopted and the time of the contract was for one year, or until November, 1914. Over 200 miles were maintained this year at an average cost of $28 per year per mile. For the year from November, 1914, to November, 1915, the benefit of the maintained roads was so well understood by the citizens that 560 miles were under contract at an average cost of $24.35 per mile per year.

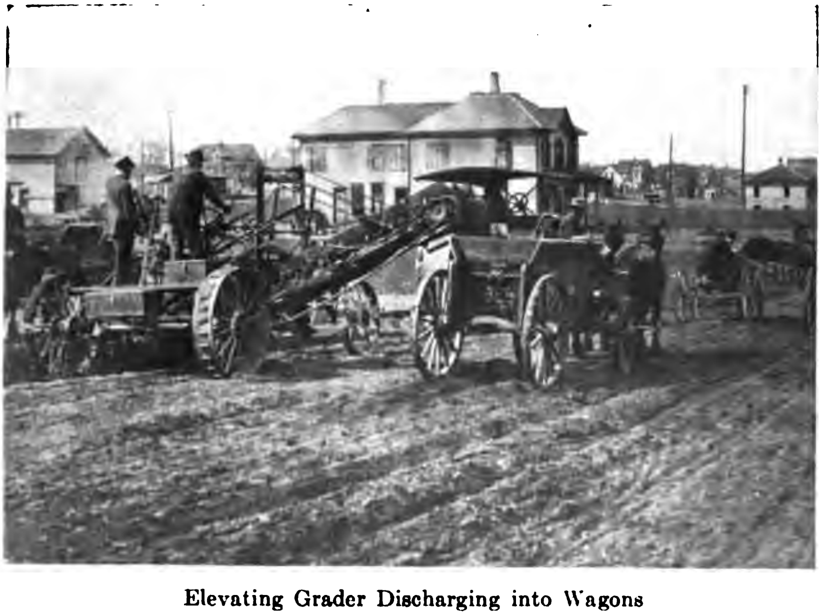
In November, 1915, a two-year contract was entered into, which the county may revoke for non-performance of the obligation at the end of the first year. About 520 miles are now under contract, at prices ranging from $12 to $40 per mile per year, the average being $22.10. It is expected this mileage will soon be increased. Originally a contractor was allowed to have charge of 8 miles, but now he is not allowed to contract for more than 4 miles of road. Under the 1915 contracts the contractor must trim the branches which overhang and interfere with travel on the roadway; keep the roadway between ditches free from shrubbery and weeds; keep the ditches clean, free from obstructions, and at all times capable of carrying the water. "He shall by June 1 each year grade the roads with dump scraper, grader, drag and ditcher, or in any way he may see fit, so that the center of the roadway shall be crowned so that the water will flow from the center of the road to the side ditches, and at no place will the water stand on the road or run down the road. The road shall be dragged from ditch to ditch at each dragging, when the road is wet, but not sticky."

A record of the number of draggings is kept by the county engineer on cards which, before mailing by the contractor, are countersigned by the rural route carrier or a reliable citizen. The contractor also hauls material and constructs all culverts and bridges of 10-foot span or under, and keeps the approaches to and the floors and abutments of all bridges and culverts on his road in good traveling condition. An analysis of these contracts shows that where the contract has been faithfully executed there is a decrease each year in the cost per mile, mainly because the farmer contractor has learned from experience that continuous maintenance makes a lower cost of time and labor each succeeding year.

In the semi-arid regions, the soil is often of a very light nature, so lacking in adhesive qualities that strong winds or flowing water erode it and travel abrades it rapidly into fine dust. It is in its best condition to carry travel when it is moist, but if it becomes saturated with water it is almost impassable. Chuck holes a foot deep are formed in dry weather in an earth road through such soil, and as they become filled with light dust they are a serious impediment to easy travel. Clay or gravel containing clay improves the roads when worked into them. The ditches should be wide and shallow, rather than deep, and the crown should be rather low for an earth road, in order to retain moisture in the roadbed. For the same reason, all grading and ditching are best done just before or during the rainy season, in order to have plenty of water to pack the soil. On account of the pulverulent nature of the material, the ends of all culverts



Elevating Grader Discharging on Roadway



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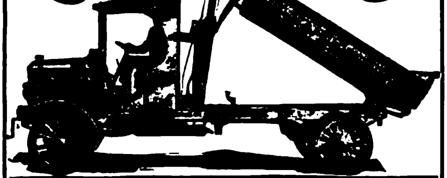

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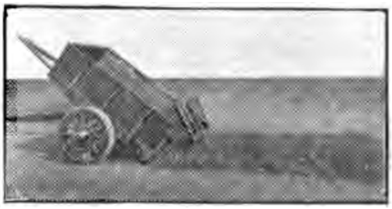

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must be planned carefully and riprap or some other material placed to prevent erosion about the inlets and outlets. The main problem with earth roads in such soils is to keep the roadbed damp and to incorporate with it adhesive or fibrous material which will act as a binder.

Sand-Clay Roads

The grains of which sand is composed are usually hard and tough and able to resist abrasion if held securely in place. In an asphalt pavement they are held by the asphalt and a wearing surface of great resistance to abrasion results. In a sand-clay road they are bound together by clay in a less firm manner but one giving excellent results on well-drained roads carrying light traffic. The aim of the builder of such a road is to employ just enough of the stickiest clay at his command to fill the pores of the sand and to mix these materials together so thoroughly that there are neither lumps of clay nor pockets of loose sand left in the surfacing. This gives the maximum amount of hard sand to carry the traffic and the minimum amount of clay to bind it. More sand makes a less durable road and more clay makes one which becomes soft more rapidly when wet.

There is a great difference in the value of different clays for such work. Some of them become dough-like when mixed with a certain amount of water and can be molded into objects which retain their shape after drying. If these molded objects are immersed in water they will retain their form for a long time. These varieties are called "plastic clays" and the most plastic are called "ball clays." There are other varieties which fall to pieces more or less quickly when wet, as quicklime does, and they are therefore called "slaking clays." They are more easily mixed with sand than the plastic clays but they have much less binding power and a road built with them is less durable when dry and more easily rutted when wet. The amount of clay to be used can be determined by a simple field test described as follows by Andrew P. Anderson:

> From typical samples of each of the available clays, test mixtures, varying by one-half part, are made with the sand so that each clay is represented by a set of mixtures ranging by successive steps from one part sand and three parts clay to four parts sand and one part clay. These are worked up with water into a putty-like mass and from each mix two equal quantities are taken and rolled between the palms of the hands into reasonably true spheres, labeled and placed in the sun to dry. When thoroughly baked, a set of spheres representing any one clay is placed in a flat pan or dish and enough water poured gently into the pan to cover them, care being taken not to pour the water directly on the samples. Some samples will begin to disintegrate immediately. Those breaking down

most slowly contain most nearly the proper proportion of sand and clay for the particular materials. The relative binding power of the various clays may then be determined by comparing the hardness and resistance to abrasion of the various dry samples having the correct proportion of sand and clay, as determined by the water tests.

In February, 1917, representatives of 21 state highway departments and of the U. S. Office of Public Roads recommended the following mixtures for hard, medium and soft classes of sand-clay roads.

Hard class: Clay, 9 to 15 per cent; silt, 5 to 15 per cent; total sand 65 to 80 per cent; sand retained on a 60-mesh sieve, 45 to 60 per cent.

Medium class: Clay, 15 to 25 per cent; silt, 10 to 20 per cent; total sand, 60 to 70 per cent; sand retained on a 60-mesh sieve, 30 to 45 per cent.

Soft class: Clay, 10 to 25 per cent; silt, 10 to 20 per cent; total sand, 55 to 80 per cent; sand retained on a 60-mesh sieve, 15 to 30 per cent.

By clay is meant material separated by subsidence through water and possessing plastic or adhesive properties; it is generally below 0.01 mm. in diameter. By silt is meant the fine material other than clay which passes a 200-mesh sieve and is generally from 0.07 to 0.01 mm. in diameter. By sand is meant the hard material which passes a 10-mesh sieve and is retained on a 200-mesh sieve, and is generally from 1.85 to 0.07 mm. in diameter.

The larger part of the following explanation of the construction of sand-clay roads was prepared by W. S. Keller, State engineer of Alabama, where many miles of sand-clay roads have been built and are giving good satisfaction:

Every farmer who lives in a section of country where both sand and clay are prevalent, is more than likely traveling over a section of natural sand-clay road but is ignorant of the fact. He can call to mind some particular spot on the road he travels, though it may not be more than 100 feet in length, that is always good and rarely requires the attention of the road hands. Good drainage will be noticed at this place and if he takes the trouble to investigate, he will find that a good mixture of sand and clay forms the wearing surface. If this 100 feet of road is always good then the entire road can be made like it provided man will take advantage of the lesson taught by nature and grade the road so that the drainage will be good and surface the balance of the road with the same material. If it is not possible to find this ready mixed surfacing material convenient to the road it may be possible to find the two ingredients in close proximity. In case the road after grading shows an excess of sand, clay should be added, or in case clay predominates, sand should be added to produce good results. There are four general ways in which sand-clay roads may be built:

1. Ready mixed sand and clay placed on clay, sand or ordinary foundation.
2. Sand and clay placed on soil foundation and mixed.

3. Clay hauled on a sand foundation and mixed with the sand.
4. Sand hauled on a clay foundation and mixed with the clay.

Taking up the various methods in order:

1. A natural mixture of sand and clay can often be found where the two materials are found separate. The most important point is to know the natural mixture when seen. The very best guide to this is to find a natural piece of good road. A sample from the best of this good section will, by comparison, indicate what is required, close to the road to be surfaced. This natural mixture of sand and clay can be noticed where red clay and sand crop out, usually well up in the hills, having in ditches and cuts the appearance of red sandstone. A good stratum of well mixed sand and clay will stand perpendicular in cuts and ditches, resisting erosion almost as well as sandstone. A test of the best natural sand-clay mixtures will show the sand forms about 70 per cent of the whole. The test is very simple. Take an ordinary medicine glass, measure 2 ounces of the mixture into the glass and wash out the clay. Dry the remaining sand and measure again on the medicine glass. The loss will be the amount of clay originally contained in the mass.

Before placing any sand-clay on the road, the road should be graded to the desired width. The surface of the graded road should be flat or slightly convex. The sand-clay should be put on from 8 to 12 inches in thickness, depending on the character of the subgrade or foundation. With a hard clay for foundation, 8 inches of sand clay will suffice. If the subgrade is sand it is well to put on as much as 12 inches of the surfacing material. After a few hundred feet of surfacing material has been placed, a grading machine should be run over it to smooth and crown the road surface before the top becomes hard and resists the cutting of the blade. It is a good plan to turn the blade of the machine so as to trim the edges of the surface part, discharging the excess sand and clay onto the earth shoulders. After one round trip with the blade turned out, the remaining dress work with the machine should be with the blade turned in, with the exception of one trip down the center of road with the blade at right angles to the axis of the road for the purpose of distributing any excess of material left in the center.

After the machine work, it is well to follow with a drag, which smooths any rough places left by the machine and leaves the road with a smooth, even surface. A sand-clay road, unlike other roads, cannot be finished in a short space of time. It can be left in an apparently finished condition with a hard smooth surface, but it will be found on close examination that the hard surface is in reality only a crust, below which there are several inches of loose material. After the first hard rain the crust softens, the road becomes bad and the work appears to be a failure. This, however, is just what is needed to make it eventually good. After the surface has dried until the mass is in a plastic state, it should be dragged until the surface is once more smooth, with proper crown, and should be kept this way by dragging at least once a day until the sun has baked it hard and firm. The mistake of keeping traffic off during this process of resetting should not be made. The continuous tamping of the wheels of wagons and hoofs of horses is just what is needed to compact the sand-clay into a homogeneous mass. The ordinary roller is not very effective in this work, but corrugated rollers have given excellent results. One type which is widely used has 18 cast-iron wheels weighing 300 pounds each, which compress the bottom of the mixture first. As the material becomes more and more compact the wheels ride higher and higher and finally the surface is so hard that the roller does not sink into it at all. A drag is an indispensable machine in the construction of any kind of sand clay road.

2. Sand and clay placed on a soil foundation and mixed. This is necessary where the old road has neither a sand nor clay foundation and it is impossible to find the two ingredients ready mixed, but possible to get both in separate state near at hand. The clay should first be placed on the road to a depth of 4 inches and the required width. It is not wise to place more than a few hundred lineal feet of clay before the sand is hauled, as the clay rapidly hardens and makes the mixing process difficult. After, say, 400 feet of clay has been placed, the clay should be broken by means of a plow and harrow, if it has become hard, and sand to a depth of 6 inches placed on it. This should be plowed and harrowed in thoroughly. This is best done immediately following a rain, as the two can be more satisfactorily mixed. The traffic aids the mixing and should be encouraged on the road. After the mass appears to be well mixed, the road should be properly shaped, as previously explained. The road should be given watchful attention and should sand or mud holes appear, a second plowing and mixing should be given it.

3. Clay hauled on a sand foundation and mixed with the sand. The mixing process is similar to that described under second head. It is only necessary to add that as the foundation is sand, a little more clay will be necessary than where the foundation is of clay or soil.

4. Sand hauled on a clay foundation and mixed with clay. The clay foundation should be plowed to a depth of 4 inches and harrowed with a disk or tooth harrow until the lumps are thoroughly broken or pulverised. Sand should then be added to a depth of 6 inches and mixed as before described.

Sand and clay can be mixed best when wet, but as most road construction is done in the summer months, it is necessary to do most of the mixing dry and keep the road in shape after the first two or three rains, while the passing wagons and vehicles give the road a final wet mixing. A sand-clay road is the cheapest road to maintain, for the reason that it can be repaired with its own material. With a drag or grading machine ruts can be filled with material scraped from the edges, whereas on gravel or macadam roads, this is not possible. The repairing of these roads can be done almost exclusively with the drag, only enough hand work being required to keep the gutters open and the growth of weeds cut on the shoulders. Holes are repaired by adding more sand-clay, and when many of them appear fresh sand-clay should be spread over the surface of the road. If the road gets into really bad condition, the roadbed should be plowed up, reshaped and fresh sand-clay added. This is unnecessary where the road is maintained properly and the travel is not too heavy for the type of construction.

GRAVEL ROADS[1]

At the close of 1914, 45 per cent. of the surfaced roads in the United States were gravel roads, as shown in detail in a table in Part III of this volume. The presence of good gravel in many parts of the country and the low cost of constructing and maintaining gravel roads will make them a leading type for many years to come.

Some gravels are much better for road construction than others. In Michigan, where three-fifths of the surfaced roads are built of gravel, the value of this material for the purpose is held to vary with the percentage of pebbles in it, the road-building value of the rock of which the pebbles are composed, and the cementing properties of the fine material mixed with the pebbles. In this State at least 60 per cent by weight of the gravel for state reward roads must be pebbles larger than ⅛-inch. No pebbles larger than 2½ inches are used in the bottom of the road and none larger than 1½ inches in the top. The binder required for holding the pebbles together is clay, uniformly mixed with the pebbles, free from lumps, and amounting to not over 10 per cent of the total weight of the gravel.

There is a large mileage of gravel roads in New Jersey, and as a result of experience with them, the State highway department rejects gravel with over 5 per cent retained on a 1½-inch circular opening and over 35 per cent retained on a ½-inch circular opening. Three grades are recognized. Grade A is a pebble gravel with a clay binder with not less than 25 nor more than 35 per cent retained on a ¼-inch circular opening, not less than 40 nor more than 60 per cent retained on a 10-mesh sieve, not less than 8 nor more than 20 per cent passing a 200-mesh sieve, and the balance a fairly well graded sand. Grade B is a sandy gravel depending upon oxide of iron for its cementing properties, with 20 to 40 per cent retained on a 10-mesh sieve and 10 to 25 per cent passing a 200-mesh sieve. Of this material passing a 200-mesh sieve, at least 40 per cent must be soluble in a 1:3 dilution of hydrochloric acid. Grade C is gravel which does not fall under either of the previously mentioned grades but is approved by the engineer for the bottom part of gravel roads.

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[1] Revised by Frederic E. Everett, State Highway Commissioner of New Hampshire.

In Illinois, the State highway department requires the gravel to be rather uniformly graded in size from fine material to pebbles that will just pass a 3½-inch ring, and not over 15 per cent of the mass (exclusive of clay) passing a ⅛-inch ring. It must not contain over 5 per cent of loam but it must have 15 to 25 per cent of clay by dry measure. If a local gravel does not form a good bond, the contractor must supply a bonding gravel for the top ¾-inch of the road. All of this material must pass a 1-inch screen and contain 40 per cent of pebbles retained on a ½-inch screen and from 20 to 30 per cent of clay and loam, not more than 5 per cent being loam.

The variations in these specifications show the range of properties of the materials found useful by experience. Few attempts have been made to prepare a general specification for road gravel on this account. The following requirements were adopted by the American Society of Municipal Improvements in 1916 and recommended by the Committee on Materials for Road Construction of the American Society of Civil Engineers:

> Two mixtures of gravel, sand and clay shall be used, hereinafter designated in these specifications as No. 1 product (for top course) and No. 2 product (for middle and bottom courses.)
>
> No. 1 product shall consist of a mixture of gravel, sand and clay, with the proportions of the various sizes as follows: All to pass a 1½-inch screen and to have at least 60 and not more than 75 per cent retained on a ¼-inch screen; at least 25 and not more than 75 per cent of the total coarse aggregate (material over ¼-inch in size) to be retained on a ¾-inch screen; at least 65 and not more than 85 per cent of the total fine aggregate (material under ¼ inch in size) to be retained on a 200-mesh sieve.
>
> No. 2 product shall consist of a mixture of gravel, sand and clay, with the proportions of the various sizes as follows: All to pass a 2½-inch screen and to have at least 60 and not more than 75 per cent retained on a ¼-inch screen; at least 25 and not more than 75 per cent of the total coarse aggregate to be retained on a 1-inch screen; at least 65 and not more than 85 per cent of the total fine aggregate to be retained on a 200-mesh sieve.

It is evident that the most useful information concerning the value of any gravel for road work is obtained by examining a road built of it. If there is a good gravel road and the source of this gravel is not known, a sample of the gravel can be analyzed mechanically by a portable sand tester, and the gravel deposits in the vicinity tested by the same instrument until one is found showing about the same properties. An exact agreement should not be expected. Tests of the gravel in a satisfactory road in the State of Washington and of the material in the pit from which it was obtained gave the following variations:

Mechanical Analyses of Identical Gravel Sampled at Pit and in the Road

PASSING	PIT	ROAD	PASSING	PIT	ROAD	PASSING	PIT	ROAD
	per cent	*per cent*		*per cent*	*per cent*		*per cent*	*per cent*
200 sieva	4.1	6.4	30 sieve	10.2	6.5	2 sieve	3.5	8.3
100 sieve	8.0	8.1	20 sieve	14.7	12.1	¾ inch	1.2	5.7
80 sieve	6.6	4.7	10 sieve	14.5	12.7	1 inch	......	1.9
50 sieve	16.3	7.4	8 sieve	2.6	3.4	1¼ inch	......	6.4
40 sieve	13.1	6.9	4 sieve	5.2	9.5	1½ inch	......	......

Where coarse gravel is composed of rock pebbles giving a cementitious powder some engineers consider it unwise to use enough clay binder to fill the voids. If roads of coarse gravel bound with a large amount of clay are used by many automobiles the pebbles become dislodged and the road does not become hard, it is claimed. Consequently these engineers prefer to use a smaller amount of clay and to allow the traffic to wear down the road and produce the necessary binder by attrition and internal disintegration of the mass of gravel. This process makes it necessary to maintain the road carefully for some time after its completion, but is stated to give a better road eventually with some classes of gravel.

In New England, where gravel roads have been built extensively, it is generally considered safe to use on roads for light traffic the gravel from any pit where the face stands vertical and has to be loosened before it can be shoveled. Other gravels usually have to be supplied with a binder. It is always desirable to make a careful search for all deposits of gravel and an examination of the quality of each before deciding upon the deposit to use. In Dubuque County, Iowa, for instance several months were spent in such an investigation because the local limestone was too soft for road use. Finally a satisfactory pit was found 1¾ miles from the road to be improved, and by transporting it on a light narrow-gauge railway to the road and then distributing it by branches of this railway and by motor trucks and dump wagons, its cost on the road was kept down to a satisfactory figure.

Preparing the Gravel

The management of the gravel pit should receive enough study and attention to make sure that the material is delivered to the wagons or cars at the lowest cost. The organization for the purpose will depend upon the location of the pit, the quality of the gravel and the quantity of material to be taken out. Where there is only a small percentage of the gravel which is over size, and the remainder runs a uniformly good mixture, the large stones can be removed by a flat gravel screen, or, on small works, can be forked out during loading. It is not always necessary to go to the expense of screening. With a good foreman in the pit it may be possible to get a proper mixture of the material from a pit where the gravel lies in strata of different sized pebbles, provided there is also a good foreman on the road, so that the strippings, if any, will be placed on the shoulders and the overlarge material will be used for foundations in low places.

Where there is a considerable proportion of overlarge stone in the gravel it is customary to set up a crushing and screening plant at the pit. For example, Kane County, Illinois, has an outfit consisting of a jaw crusher, screen, elevator and storage bin holding 15 cubic yards. The gravel is first screened, because by taking out the material of suitable size for road work only the large stone is fed to the crusher and its capacity is thereby much increased. The presence of the small stone in the crusher tends to clog it and retard the breaking of the large stone. The screened and crushed material is discharged by gravity from the bins into the 5-yard motor trucks which are used for delivering it. The pit material is delivered to the screen by a belt conveyor, 18 inches wide and 40 feet long. One end of the belt is under a platform having a hopper over the belt. The gravel is brought by slip scrapers to the platform and dumped through the hopper onto the conveyor.

In some plants of this character the gravel is run over a bar screen or "grizzly" which holds back all oversize stone and delivers it to the crusher. This keeps the large stone entirely out of the screen. In Wisconsin work the screen has ½-inch perforations for the first half of its length and 1¾-inch perforations for the second half, giving three sizes of gravel. The jaws of the crusher are set to give about equal parts of the two coarser sizes separated by the screen.

As the pebbles composing gravel are rounded and do not lock together as well as broken stone, it is customary to use somewhat smaller sizes of gravel than of crushed stone. Gravel obtained from beaches and rivers is usually more rounded than that from pits and consequently may not be so good for roads, unless suitable binding gravel can be used for a wearing surface or limestone screenings or other good binding material can be used with it.

Pit-run Gravel Roads

Many miles of gravel roads have been built by dumping the gravel on the roadbed, spreading it roughly and allowing traffic to consolidate it. The consolidation is a tedious process, but good roads often result in the end, particularly if the road is kept well dragged so that ruts and holes are prevented. Better results are obtained, however, if the gravel is rolled after it is spread. The loads of large stone should be dumped at the low or soft places on the roadbed. In deep, mealy sand, the subgrade is sometimes covered with marsh hay, wet sand or fine

Cubic Yards of Loose Gravel Required to make One Mile of Road of Different Widths and Thicknesses. Based on Table of Commissioner of Public Roads of New Jersey.

WIDTH	THICKNESS OF ROAD AFTER CONSOLIDATION, INCHES						
	6	7	8	9	10	11	12
feet							
6	880	1,027	1,173	1,320	1,467	1,613	1,760
7	1,027	1,198	1,369	1,540	1,711	1,882	2,054
8	1,173	1,369	1,564	1,760	1,956	2,151	2,346
9	1,320	1,540	1,760	1,980	2,200	2,420	2,640
10	1,467	1,711	1,956	2,200	2,444	2,689	2,934
11	1,613	1,882	2,151	2,420	2,689	2,958	3,226
12	1,760	2,053	2,346	2,640	2,933	3,227	3,520
13	1,807	2,224	2,542	2,860	3,178	3,496	3,614
14	2,054	2,396	2,738	3,080	2,422	3,764	4,108
15	2,200	2,567	2,933	3,300	3,667	4,033	4,400
16	2,346	2,738	3,128	3,520	3,912	4,302	4,692
17	2,493	2,909	3,324	3,740	4,156	4,571	4,986
18	2,640	3,080	3,520	3,960	4,400	4,840	5,280
19	2,787	3,250	3,716	4,180	4,644	5,109	5,574
20	2,933	3,422	3,912	4,400	4,888	5,378	5,866

Cubic Yards of Crushed Stone or Gravel Required to Give Different Depths when Lying Loose on One Mile of Roadways of Different Widths. Based on Table of Wisconsin Highway Commission.

WIDTH OF SURFACE	DEPTH OF LOOSE MATERIAL, INCHES							
	1	1¼	1½	2	3	4	5	6
feet	*cu. yds.*	*cu. yds.*	*cu. yds.*	*cu. yds.*	*cu. yds.*	*cu. yds.*	*cu. yds.*	*cu. yds.*
8	130	160	195	260	391	521	652	782
9	147	180	220	294	440	587	734	880
10	163	200	244	326	489	652	816	977
12	196	240	293	392	587	783	980	1,171
14	218	280	342	436	684	913	1,141	1,369
15	244	300	366	488	733	979	1,222	1,466
16	261	325	391	522	782	1,043	1,304	1,565
18	294	367	440	588	880	1,174	1,468	1,760
20	326	400	488	652	978	1,304	1,632	1,954
22	359	440	537	718	1,076	1,434	1,796	2,148
24	392	480	584	784	1,174	1,564	1,960	2,342

Weight in Pounds Per Cubic Yard of Sand and Gravel. From "Mineral Resources of the United States, 1915."

STATE	SAND	GRAVEL	STATE	SAND	GRAVEL	STATE	SAND	GRAVEL
Alabama......	2505	2790	Massachusetts	2710	2810	Oregon.......	2620	2880
California.....	2645	2895	Michigan.....	2895	2985	Pennsylvania	2500	2680
Florida.......	2605	2680	Minnesota....	2865	2880	Texas........	2695	2910
Illinois........	2820	3005	Missouri......	2680	2840	Washington..	2930	3065
Indiana.......	2700	2945	New Jersey...	2600	2730	W. Virginia..	2570	2780
Iowa..........	2720	2850	New York....	2590	2760	Wisconsin....	2800	2970
Kentucky.....	2580	2830	Ohio..........	2700	2830	Average......	2665	2820

NOTE: The average weights were obtained from 670 producers of sand and 560 producers of gravel in all parts of the country; the range was from 2200 to 4000 pounds for sand and from 2200 to 4200 pounds for gravel. The weights given for each state are the averages of the reports from ten or more producers in that State.

brush to hold the gravel. The stone should be well raked and no stone larger than 2 inches should be allowed in the top of the road.

It is best to lay the gravel in two courses, each 5 or 6 inches thick when loose. The spreading of the first course begins at the place on the road where the gravel reaches it and in this way the material is consolidated by the teaming over it. When this is very hard work enough clay is sometimes added to pack the gravel. Some engineers require this course to be harrowed. It is desirable to shape this course with a grading machine and roll it, but if the equipment is not available it can be improved by using a drag or a road plane, as described on page 266.

After a considerable stretch of the bottom course has been finished, the second course can be started, beginning at the end farthest from the gravel pit, so as to have the teaming do as much consolidation work on the bottom course as possible. Some engineers require the entire bottom course to be finished before the second is started. It is best to harrow the second course because pit-run gravel usually needs good mixing and the harrow will bring the large stones to the surface, so they can be thrown aside. If the gravel needs a binder the harrowing will help to distribute it evenly. If too much clay is added the road is likely to rut in wet weather and be dusty in dry weather. After the harrowing, the surface is shaped with a grader, if one is available, or with a drag or plane. It should then be rolled, and with some gravel the rolling gives the best results if the road is first wet.

Gravel is a surfacing material; it will not make a defective roadbed good, although it may temporarily improve it. Consequently it is best to allow a new roadbed to be used as an earth road for a year, so it will have a chance to settle. If it is kept well dragged during this seasoning period, it will become hard enough to sustain the gravel. If it is known that gravel will be placed after a year's use, the earth road should be dragged to a very flat crown, in order to prevent too much crown in the gravel road. When gravel must be placed on a fresh roadbed, it is sometimes advisable to lay a 6-inch course and allow that to become consolidated by traffic before the second course is laid. If there are any defects in the roadbed they will become apparent during the early use of the road and can be repaired before the completion of the surfacing. If only the bottom course is laid the first season it should be well dragged, for inequalities in the bottom course are usually reproduced in the upper course, no matter how carefully the latter is laid and shaped,

There are two methods of placing gravel. That usually employed on pit-run gravel roads is called the feather-edge method. The roadbed to receive the gravel is graded to a very small crown and the gravel is spread on it to a nearly uniform thickness until within about 12 inches of the edge, when the bed is sloped off to a mere row of pebbles at the edge. In the second method of construction, a shallow trench, sometimes called a "gravel bed" or a "box," is excavated in the top of the roadbed, and the gravel deposited in it. If it rains this trench is likely to become muddy and to prevent this drainage channels should be cut through the shoulders to the side ditches. Bank gravel will become consolidated and shed water more quickly than stream gravel and it is better suited for the trench method in consequence. The feather-edge method is less expensive and more easily carried on if traffic must be permitted on the road during construction.

The following explanation of the construction of a two-course feather-edge gravel road was written by H. E. Bilger, road engineer of the Illinois Highway department:

> When the bonding material in the gravel is nor entirely satisfactory with respect to both quality and quantity, it is usually advisable that two-course construction be adopted. Whether or not the work is to be done by contract, it is important that there be used some positive and accurate method of determining the volume of gravel delivered upon the roadbed. There are several methods by which this can be accomplished, but experience seems to indicate that by the use of temporary side-board forms the desired results can be assured and this method is not uneconomical.
>
> Upon the satisfactory completion of the roadbed there should be set thereon, true to line and grade, temporary side forms having a width equal to the depth of the loose gravel, which should be shown on the plans. These boards should be held in place by stakes at such intervals as will prevent lateral deflection greater than about 3 inches from the true alignment. Whether the gravel is hauled by wagons, motor trucks, industrial

railways, or other vehicles, it may be dumped directly upon the subgrade. After there has been placed upon the subgrade a sufficient quantity of gravel for the lower half of the road, it should be distributed to a uniform depth by the use of a blade grader, drag scraper, or otherwise. While this course is being spread, all the larger stone should be raked or otherwise placed directly in contact with the subgrade. Upon this course of gravel there should be placed such an amount of bonding clay as may be necessary in order that the gravel will comply with the specifications.

After the gravel has been spread it should be thoroughly harrowed several times over until the cores formed by dumping it have been entirely loosened up to a density equal to that in the other portions of the gravel. The importance of this thorough harrowing can scarcely be overestimated, for in order to secure the results it is essential that the voids in the gravel be reduced to a minimum, which means that a maximum density of material must be obtained, and this density is closely approached by harrowing until the pebbles of the several sizes become so placed as to occupy the spaces between those of a large size. The cost of this harrowing as compared with the results obtained is practically negligible, and if necessary it would actually be more advisable to do away with the rolling and retain the harrowing than to do away with the harrowing and retain the rolling. The harrow should be of the stiff tooth type, and should have metal teeth at least 1-inch in diameter, extending about 6 inches below the frame. The spacing of the teeth should be such as will admit of the free passage of the stones between them, and yet so displace them as to produce the density desired. The design of the harrow should provide a weight of from 8 to 12 pounds upon each tooth.

After the second course of gravel has been placed, it should be spread until its upper surface comes flush with the top of the side forms and its cross section conforms to that desired. The forms should then be removed and the gravel allowed to take its natural position. Upon this second course there should be distributed the necessary quantity of bonding clay. It should then be thoroughly harrowed several times, as before, until the cores formed by dumping the gravel have been entirely loosened up and the clay has been uniformly distributed throughout. The harrowing should continue until a uniform density of material is obtained throughout the upper course.

Having done this, the earth shoulders should be shaped by the necessary cutting and filling until the cross section conforms approximately to the finished work. Material other than the natural earth should not be used in forming these shoulders, and all vegetable matter should be strictly prohibited from entering into the work. Upon having shaped the shoulders, the graded roadway over the entire width should be rolled several times over until it is thoroughly compacted, forming a firm, smooth surface, free from waves and according to the requirement of the plans. The rolling should begin at the extreme outer edges of the shoulders and should work toward the center, at each rolling of the gravel allowing an overlap of one-half of the width of one of the rear wheels, and each wheel should cover the entire gravel surface.

Should the condition of the gravel or its bonding material be such as not to compact readily under the action of the roller, sprinkling or other means should be employed to compact the gravel as the engineer may direct. The speed of the roller should not exceed about 100 feet per minute. It is quite probable that after rolling there will appear either on the shoulders or the gravel certain depressions and other irregularities. To correct these defects suitable material should be added or removed and they should then be rerolled. The finished surface should conform to the cross section shown on the plan and should present a smooth and even appearance. Should the gravel, with its natural or artificial mixture of bonding clay, for the upper 4 inches of the road, be of such character that it will not insure a satisfactory wearing surface with a dense body and uniform texture, a 1-inch coating of bonding gravel should be applied uniformly over the entire surface of the gravel road. This bonding gravel should then be raked and rolled into the road surface until all the interstices are filled and the surface is smooth, of a uniform texture and free from waves.

Screened Gravel Roads

In some States, preference is given to gravel roads built like macadam roads, the gravel being screened so that the courses will be composed of material of different sizes. This is the case in Wisconsin, for instance. In that State, except on sandy roadbeds, construction is started at the end of the road farthest from the gravel supply, when screened gravel is used, because the roller can be run continuously without interfering with the teams bringing the gravel. The first course consists of material from 1¾ to about 3 inches in size spread to a loose depth of 6 inches. The voids are filled with gravel under ½-inch in size and the road is then rolled. This course is laid for a distance of about 400 feet, and the second course is then started. This consists of about 5 inches of ½ to 1¾-inch stone with the voids filled like those of the bottom course. The surface is shaped with a grader and rolled and flushed like a macadam road.

In many instances better results are obtained, according to J. T. Donaghey, chief inspector of the Wisconsin highway commission, by crushing the gravel fine enough for practically all the material to pass a 1¾-inch ring. The screen is partly jacketed so that just enough of the material passing the ½-inch openings is carried into the ½ to 1¾-inch size to fill the voids in the latter. This mixture is used in both the bottom and top courses and results in a type of road which Mr. Donaghey considers more easily built, more satisfactory and more cheaply maintained than any other gravel type. Where clay is added to assist in binding or there is naturally an excessive amount of clay in the gravel, it is advisable to place a covering of sharp sand or gravel on the finished surface to protect it until the excess clay has worked to the surface and washed off.

In the work in Kane county, Illinois, to which reference has already been made, George N. Lamb, county superintendent of highways, places the lower course in a trench or box and rolls it and the shoulders until there is no difference of elevation where they meet. The second course is then placed with the edges feathering out a foot or two over the shoulders.

The following instructions for preparing the subgrade were issued in 1914 by the Wisconsin highway commission:

Starting at the desired point, set two stakes opposite the reference stake, the distance between them being the width of the new road. To do this, refer to the grade sheet, which gives the distance from the side stake (placed when the survey was made) to the center of the new road. Subtract from this distance one-half the desired width of road and put in a stake with inside edge at this distance from the reference stake. Opposite this stake place another with its inside edge distant the width of the road from the inside edge of the first one. All stakes for subgrade should be made of ½-inch round iron about 24 inches long, and about twenty-five should be kept on each surfacing job. Stake out 700 or 800 feet at a time. Be sure that the stakes are in line, except at bends or on curves. Usually curves will have to be staked out by eye to get good results.

With a road plow cut as close to the inside edge of stakes as possible withour disturbing them, turning the furrow toward the center of subgrade. Plow about 5 inches deep. One furrow on each side is generally sufficient. Plow should be equipped with shoe or wheel and coulter. If a rooter is used, three furrows on each side will usually be necessary. Make first cut about 5 inches deep as close to stakes as possible, the next 6 inches nearer the center of the road. Drop the shoe down so rooter will run about 3 inches deep for the third cut, working 6 inches nearer center of subgrade than previous furrow.

A light grader that can be handled with two horses is best for shaping. Use with the blade so set as to move the plowed ground from the center of trench or subgrade on to the bank outside of stake line. This work cannot be accomplished neatly with the grader alone, as some of the earth will roll back into the trench under the best of conditions. Make the trench deep enough. The depth at the sides should be at least the total loose depth of the two courses of material and more than this on sandy soils. It is much easier to throw out excess material with the road grader after the surface is laid than it is to bring extra material up from the ditches or to haul it in by wagons during the finishing when the trench has not been made deep enough to hold the stone. Nothing is more essential than a good solid shoulder, and the time to get it is before material is placed in the trench. In clay soils after making the trench, plow drains through the shoulders every 50 feet on both sides and every 25 feet at low points between hills and immediately clean them out so they will drain the subgrade in case of rain.

The following procedure is not advised, as it is usually the most expensive way of getting shoulders. If the road has once been covered with crushed stone or gravel, and it is not desired to tear up the old surface, shoulders can be brought up to the stakes by bringing in dirt with the road machine from the side banks or from the ditches (if the latter material is fit to use), or can be hauled in with wagons. If the old road has a crown of one inch to the foot, it will take approximately 1,100 cubic yards of compacted material per mile to build up 6-inch shoulders and retain the minimum width of 20 feet on top. The cost of hauling and placing this material is usually very much greater than the value of the stone or gravel saved. As a matter of fact, no material is wasted if the subgrade or trench is cut in the old surface, the stone or gravel thrown out making an excellent shoulder. Failure is inevitable if an attempt is made to build a gravel or stone road with a heavy roller without first getting proper shoulders to support the material while it is being rolled.

Straighten up stakes and drive them firmly. Tie a chalk or binder twine line to stakes on each side so line will draw on inside faces of stakes, drawing it tight. It is usually best to put in additional stakes at 50-foot points so this line will not sag. These lines are to guide the laborer in trimming the shoulders so the edges will be straight and the grade uniform. On a 9-foot road, if these lines are set 7 inches above center of subgrade, they will be 1 foot higher than the bottom of trench at the shoulder. On a 15-foot road set lines 6 inches above center of subgrade. They will then be one foot higher than the bottom of trench at the shoulder. The blade of an ordinary square point dirt shovel is 1 foot long and can be used by the laborer to tell when trench is deep enough at sides by setting blade of shovel up to line. When trench is finished, it should run with a uniform slope from center to edge. Clean out drainage trenches through shoulders, so that they really drain out from the trench. This will keep the trench from filling up in case it rains. It is well to widen the trench and road on the inside of curves, and to elevate the outer edge of curves.

After the subgrade has been properly shaped to the same crown (or, better, a slightly greater crown) than the finished road is to have, it should be rolled until hard, especially if recently filled. Any hollows that develop during the rolling should be filled. Roll enough, but stop before the top layer of earth starts to slip. Wet spots in the subgrade should be shoveled out, filled with good earth or cinders and rolled. Don't leave sink holes with the expectation of filling them with crushed stone. They must be dug out and refilled with good material if a firm surface is to ever be gotten at that point.

In spreading gravel or broken stone many engineers place on the subgrade wood or concrete blocks of the desired loose depth of the course. In Wisconsin, however, the material is spread by requiring a load to cover a certain length and width of surface. The foreman is given a table of the length of 9-foot road which loads of different sizes will cover and the spreader is required to

Length of Road in Linear Feet Which a Load of Stone of Given Size will Cover to the Given Loose Depths. Based on Table of Wisconsin Highway Commission.

WIDTH OF ROAD	LOOSE DEPTH	SIZE OF LOAD IN CUBIC YARDS								
		1	1¼	1½	1¾	2	2¼	2½	2¾	3
feet	*inches*	*feet*	*feet*	*feet*	*feet*	*feet*	*feet*	*feet*	*feet*	*feet*
8	3	13.5	16.9	20.2	23.6	27.0	30.4	33.7	37.1	40.5
	4	10.1	12.6	15.2	17.7	20.2	22.6	25.3	27.8	30.3
	5	8.1	10.1	12.1	14.1	16.2	18.2	20.2	22.3	24.3
	6	6.75	8.4	10.1	11.8	13.5	15.2	16.9	18.5	20.3
9	3	12	15	18	21	24	27	30	33	36
	4	9	11.25	13.5	15.75	18	20.25	22.5	24.75	27
	5	7.2	9	10.8	12.6	14.4	16.2	18	19.8	21.6.
	6	6	7.5	9	10.5	12	13.5	15	16.5	18
10	3	10.8	13.5	16.2	18.9	21.6	24.3	27	29.7	32.4
	4	8.1	10.1	12.2	14.2	16.2	18.2	20.2	22.3	24.2
	5	6.5	8.1	9.7	11.3	13.0	14.6	16.2	17.8	19.4
	6	5.4	6.7	8.1	9.4	10.8	12.1	13.5	14.8	16.2
12	3	9	11.2	13.5	15.8	18.0	20.2	22.5	24.7	27.0
	4	6.7	8.4	10.1	11.8	13.5	15.1	16.9	18.5	20.2
	5	5.4	6.7	8.1	9.4	10.6	12.1	13.5	14.8	16.2
	6	4.5	5.6	6.7	7.8	9	10.1	11.2	12.3	13.5

make the loads cover just this length. When this method is followed it is convenient to have the loads hauled of the same size. The man placed in charge of the spreading should be selected carefully, because a large amount of money can be wasted by placing too much material on the road. The depth of the loose material should be checked as often as possible on this account.

When the gravel is bought by weight it is the Wisconsin rule to take the weight of a cubic yard of pit gravel at 3000 pounds and of crushed gravel at 2650 pounds. If the material is wet it will weigh more than when it is in a normal condition and allowance should be made for this.

Special Binders

Gravel roads are now being built for quite heavy traffic with binders giving greater toughness to the road than clay or rock powder will afford. Examination of many roads after several years of use has shown that there is less large stone and more small stone in them than when they were built. This change is considered due to the internal disintegration of the stone by the loads coming upon it, part of the reduction taking place when the road is heavily rolled during construction and part later under heavy travel. The special binders are used to hold the stone so firmly together that after the rolling of the road there will be no further internal disintegration. The method of using bituminous binders for this purpose is explained in the chapter on bituminous roads, and the method of using glutrin in the chapter on broken stone roads.

Maintenance

The maintenance of gravel roads must begin immediately after the road is thrown open to travel. A small hole in a gravel road, unless immediately repaired, soon becomes a large hole. A few large holes mean a ruined road and a large expense for resurfacing. Furthermore a gravel road, no matter how well rolled, cannot be considered finished until traffic has gone over it and tested every part. For this reason, some engineers allow traffic on the road before the roller has left it, so that any weak places may be revealed and repaired at once while the equipment is still at hand. The rounded pebbles of pit gravel do not interlock like pieces of crushed stone but are usually held together by a clay binder which is not so strong as the cementitious powder from some classes of rock. Until travel has broken down the pebbles and furnished rock powder which will act with the clay and form a rigid mass, a gravel road is not so firm as a crushed stone road and needs more maintenance.

The gravel roads of New Hampshire are used throughout the summer by a heavy automobile traffic, particularly on Saturdays and Sundays. They are nevertheless kept in good condition by the patrol system of maintenance at very low cost, considering the destructive use to which they are subject. Each patrolman has a section for which he is responsible, and a number of sections are united in a division under the general supervision of a maintenance foreman, who is in immediate charge of all maintenance work and reports to the division engineer. Each patrolman must supply a horse and dump cart, shovel, pick, hoe, rake, stone-hook, axe, iron bar, iron chain and tamp. Special tools are furnished by the State highway department. The methods of maintainance are indicated in the following quotations from the instructions issued to the patrolmen:

> One dragging in the spring is worth two in the summer. It is better to drag a mile of road several times and get it in good condition, than to drag 2 or 3 miles and not finish any part of it. Don't drag a soft section when it is so wet that the first vehicle to pass will rut it all up. First fill the holes and ruts with new material and then drag as the surface dries out. Every patrolman should have material dumped in small piles along the side of his section so that on a rainy day he can at once fill all holes and ruts in which water is collecting.
>
> When the weather is unsuitable for dragging, as during a dry spell, all patrolmen should cart on all the new material possible in order to fill all ruts and holes and resurface worn-sections. Carting is very essential during dry periods and should never be neglected. Whenever a patrolman is in doubt as to what to do next the general rule is to cart new material, for all roads are wearing out under travel and it is necessary that the surface be continually renewed to take the place of the old material that is thrown out as mud or blown away as dust.
>
> Save all the sods, leaves, rubbish, stones and refuse that you clean off your road and dump this waste material in places where the bank is steep so that by flattening the side slope there will be no need of a guard-rail, or dump the material back of a present guard-rail so that later this guard-rail can be removed.

Oiling gravel roads generally requires careful preparation of the surface because the large amount of clay binder has a tendency to interfere with the formation of a satisfactory oiled surface. Consequently the surface should be thoroughly cleaned and a comparatively light oil used. The first applications are likely to be disappointing, but if holes and ruts are filled promptly, two or three applications on carefully cleaned surfaces during the first year will eventually give a good wearing surface, provided the roadbed and gravel have been thoroughly consolidated and the traffic is not too heavy for this type of road. It is the general opinion at present that surface applications should not be made until a gravel road has had at least one year's service. The methods of doing the work are given in a later chapter.

WATER-BOUND MACADAM ROADS

Water-bound macadam roads are adapted to highways carrying moderate traffic, for experience shows that even when a large part of the traffic is motor-driven this type of construction can be maintained successfully by surface applications, as described in a later chapter. Where a gravel road is not quite able to carry the traffic, a macadam top course on a gravel base has been adopted as a standard type by the highway departments of a number of States. The following statements give the views regarding water-bound macadam held by three State highway departments having a large mileage of it under their charge:

New York: The department is still building a large mileage of water-bound macadam. Because of the presence of local material and other favorable conditions this is, in cost, the cheapest durable road which can be built; and it is the belief of the department that on all roads of ordinary or light traffic this type is still a satisfactory one for general use. Of course this type must have surface treatment with oil, and this is planned for in all cases. (Edwin Duffey, State commissioner of highways, 1916.)

Michigan: During the early existence of the department, macadam roads constituted as much as 50 per cent of the mileage constructed. As the use of the automobile became more widespread, the percentage of macadam roads built each year decreased, owing to the excessive cost of maintaining this type under the automobile traffic. Within the past two years, however, waterbound macadam roads have been again growing in favor, because it has been found possible with a bituminous surface treatment to maintain them in a condition comparable in the point of service to the higher types of roads. The first treatment, which is made after the road has been seasoned by opening it to traffic for three or four months, is essentially a part of the initial cost of construction. (Frank F. Rogers, State highway commissioner, 1916.)

Wisconsin: It is not at all an economical type of surfacing unless intensely maintained with surface treatments and a patrol system, but when so maintained gives economical service even on heavily traveled roads. (Wisconsin highway commission, 1916.)

Stone

The roadbuilding properties of different rocks are explained in the next chapter. The following notes on the selection of stone were prepared by Prevost Hubbard and Frank H. Jackson, Jr.[1] The ideal rock for the construction of a water-bound macadam road resists the wear of traffic to which it is subjected to just that extent which will supply a sufficient amount of cementitious rock dust to bind or hold the larger fragments in place. It is generally admitted that the ordinary macadam road is not well suited to any considerable amount of automobile traffic, because such traffic rapidly removes the binder without producing fresh material to take its place.

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[1] "The Results of Physical Tests of Road-building Rock," Bulletin 370, United States Department of Agriculture.

Cementing value is a necessary quality for rocks used in macadam road construction. As determined by test, cementing values below 25 are called low; from 26 to 75, average, and above 75, high. In general, the cementing value should run above 25. For rocks which show a low French coefficient of wear, however, a relatively high cementing value is more necessary than for those which have a high French coefficient. Interpretation of results of the cementing value test is subject to a number of influencing considerations. For instance, it has been found that certain feldspathic varieties of sandstone give excellent results in this test, while experience has shown that they do not bind well when used in the wearing course of macadam roads. In the case also of certain varieties of the trap group, low results are frequently shown by laboratory tests for rocks which bind quite satisfactorily upon the road, provided traffic is sufficiently heavy to supply the requisite amount of fine material. Certain granites, gneisses, and schists which are not suitable for use as binding material give good results in this test. In such cases it is usually found that the highly altered nature of the material reduces its toughness and resistance to wear to such an extent as to condemn it for use.

Experience has shown that in general the following table of limiting values for the French coefficient of wear, toughness, and hardness may be used in determining the suitability of a rock for the construction of the wearing course of a macadam road:

Limiting Values of Physical Tests of Rock Suitable for Water-bound Macadam

TRAVEL	FRENCH COEFFICIENT	PERCENTAGE OF WEAR	TOUGHNESS	HARDNESS
Light	5 to 5	5 to 8	5 to 9	10 to 17
Moderate	8 to 15	2.7 to 5	10 to 18	Over 14
Heavy	Over 15	Under 2.7	Over 18	Over 17

With relation to the limitations for hardness it may be noted that when any given value for toughness falls within certain limits which define the suitability of the material for macadam road construction under given traffic conditions, the corresponding value for hardness will fall within similar limits for hardness. In this connection it will be seen in the table that a maximum limit for hardness is only given in the case of light traffic. It has been found that the great majority of samples having a French coefficient of wear of from 5 to 8 and a hardness of over 17 are granites, quartzites, and hard sandstones, which are unsuited for use in the wearing course of water-bound macadam roads due to their lack of binding power.

The weight of a cubic yard of crushed stone varies considerably, depending upon the rock, the size to which it is broken and the amount of shaking the sample receives before its volume is measured. The range in weight of a cubic foot of solid rock is 162 to 221 pounds for trap, 165 to 200 pounds for schist, 156 to 175 pounds for felsite, 156 to 193 pounds for quartzite, 125 to 193 pounds for limestone, and 125 to 187 pounds for granite. The total range from the lightest limestone to the heaviest trap is over 75 per cent and the crushed rock will show the same variations. Consequently, when broken stone is bought by weight it should be actually weighed before estimating the quantity required for good work.

Crushed stone is the most important branch of the stone industry. The production of this material for road building in the different states is given in a table in Part III of this book. The requirements for railroad ballast and concrete as well as for road work are so large that commercial broken stone is available in many parts of the country at a lower price than the cost of quarrying and crushing local material. It is sometimes economical, even at a greater initial cost, to import stone from a distance if thereby a more durable road may be had than is possible with the use of local stone.

Much of the stone is crushed locally, usually in portable plants. These comprise a crusher with an engine and boiler, revolving screens, portable bins and an elevator to lift the stone after it is crushed into the screen and sometimes into the bins. The capacity of a crusher should be adjusted to the road roller capacity. If the crusher furnishes more stone than the roller can consolidate, it is too large to work economically. If the crusher can not supply enough stone to keep the roller at work, the latter will operate uneconomically. Furthermore the arrangements for supplying stone from the crusher to the road must be such that the expensive equipment at each end of the line will be kept operating all the time. There is some difference of opinion as to the proper capacity of a crusher, for in some sections of the country it is held that from 60 to 80 cubic yards of broken stone is as much as a single roller will consolidate properly, while in other sections it is held that a roller which does not consolidate 75 tons per day is not doing good service.

Where the stone supply is limited to ledges at infrequent intervals but little choice in the location of the crushing outfit is possible. If field stone or ledges are available alongside the road at frequent intervals a crusher can serve about two miles of road most economically. Local conditions, however, affect the proper arrangement of the plant so greatly that no precise rules can be drawn up. It occasionally happens that the availability of water for the boiler is of more importance than any other factor in determining the location of the outfit.

If possible, the crusher should be set low enough so that a platform can be built at the level of the opening into which the stone is dumped. The carts are driven onto this platform and the material is handled most economically in this manner. The men who set up the plant should have had experience in this work. Much depends on the proper alignment of the several parts and the delays in operation will be avoided if the work is done properly in the first instance.

The screens in such portable plants have three sections about 4 feet long and 30 inches in diameter. The first section has perforations which are ½-inch in diameter. The perforations of the second section are generally 1¼ inches in diameter where comparatively hard stone is used and 1½ inches in diameter where softer stone is employed. With the very soft stone used in some of the Central States, the perforations are sometimes 2½ inches, and the third section of the screen is omitted. The perforations in the third section are from 2 to 2½ inches in diameter as a rule, depending upon the maximum size of the stone which is allowed in the road, but this maximum size varies widely in different States. In New York stone up to 3½ inches in size is used in the bottom course and in Ohio pieces of sandstone as large as 6 inches in their longest dimensions are permitted in the bottom course of some roads. Stone passing a 4-inch circular opening is also permitted under some conditions. In Wisconsin the bottom course is usually made of stone 2 to 3½ inches in size; in this case the perforations in the screen are ½, 2 and 3½ inches.

The stones too large to pass through the openings in the third section of the screen drop out and are run through the crusher again. There is sometimes a conveyor to carry these tailings from the end of the screen to the crusher. The jaws of the crusher should be set to give as few tailings as possible and the length of the screen sections should be adjusted to accomplish the same purpose. The operation of the screens should be observed from time to time in order to make sure that material which should pass the openings in each section does not flow along the screen so rapidly that there is a failure to separate it out by the right section of the screen. If the screen revolves too rapidly fine material will be carried into the coarser grades. Stone purchased from commercial crusher plants is often observed to run small, the best separation occurring in the product which is obtained during a time of minimum demand. This is because more time is then given to the stone in its passage through the screens. It is impracticable to obtain a complete gradation of the sizes of stone and for this reason highway engineers often permit variations from the nominal maximum and minimum dimensions of any size. For instance the ¾-inch stone specified in New Jersey may contain up to 5 per cent of material larger than 1¼ inch and up to 8 per cent smaller than ⅝ inch, although the nominal range of size is from ⅝ to 1¼ inch.

There is no uniformity in the designation of the sizes of crushed stone; what is termed as No. 1 stone in Ohio is entirely different from No. 1 stone in New York.

Drainage

The investment in a macadam road is so great that every precaution should be taken to have the roadbed thoroughly drained. The methods of doing this were explained in the chapter on drainage. If they are not employed wherever necessary the road will inevitably become rutted and marked by holes during prolonged wet weather, and the maintenance of such places will entail an annual expenditure far greater in the end than the cost of proper drainage work.

Formerly Telford foundations were used in all wet, soggy ground under well-built broken stone roads but experience has shown that with good underdrainage equally satisfactory foundations can be built of coarse gravel. This is dumped on the bottom of the road after the soft material has been excavated to a considerable depth. The mass of gravel should be drained into the side ditches by constructing blind drains through the shoulders at intervals of not over 50 feet.

Where suitable field stone is available for a Telford foundation it is still sometimes used. The New York requirements for stone for this purpose are a thickness of not less than 1½ inches, a depth equal to the depth required for the foundation, from 6 to 8 inches, and a length not more than one and a half times the depth. The New Jersey specifications require stone 5 to 10 inches long, 2 to 4 inches wide and at least 6 inches deep. Some engineers advise placing this stone on a bed of gravel, while others believe that if gravel is available it is best to make the entire base of it and not employ Telford, since the latter is quite expensive. The stone must be set on their broader base, lengthwise across the road, and wedged by driving small stone into

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the interstices. The projecting points should be broken off with a stone hammer, the depressions in the top filled with stone chips, and the foundation rolled.

The V-shaped drain described on page 252 is a substitute for a Telford foundation which has received much favor in some states.

Sub-Grade

It is necessary to place the stone for a macadam road in a box or trench in order to roll it successfully. The method of excavating the sub-grade was described on page 294. The bottom must be slightly crowned. This is for two reasons; first to shed any water which may sink through the macadam, and second, to keep the amount of stone required for the road to the minimum actually necessary. The sub-grade must be rolled until hard in order, first, that the stone placed on it can not be driven into it and thus serve no useful purpose, and second, to turn toward the sides of the road, into the blind drains leading to the ditches, any water which may penetrate the courses of stone.

The depth of the box or trench is fixed by the desired depth of the macadam roadway. This is rarely less than 6 inches at the center and is sometimes considerably more, although there is a question whether a greater thickness than 8 inches after rolling serves any useful purpose. The harder and tougher the stone, the less need be the thickness of the road, provided the sub-grade is firm. Usually the sides of the macadam roadway are 1 to 2 inches thinner than the center.

On very sandy soils, to keep the sand from working up through the stone, a covering of clay, hay, straw, or fine brush is spread over the subgrade.

Placing the Broken Stone

It is customary to begin placing the broken stone as soon as a few hundred feet of the subgrade has been prepared to receive it, because it is undesirable to expose the rolled earth surface to the danger of drenching by rains for a longer period than is necessary.

The first course is rarely if ever spread to a greater depth than 6 inches when loose, because a roller cannot compact a deeper course of stone in a satisfactory manner. The thickness is seldom less than 4 inches. The largest size of the screened stone is used. In some states it is forbidden to dump the stone directly on the subgrade, on the ground that this leaves a mass of consolidated small stone in the center of the heap which remains almost intact when the pile is leveled. Accordingly the stone must be deposited on dumping boards about 6 feet long and 3 feet wide, from which it is shoveled to the subgrade. This is no longer a generally adopted requirement, however, but it is not unusual to require a load to be deposited in several dumps so that the least amount of shoveling and raking will be required.

Costs Per Mile Corresponding to Different Costs Per Square Yard. Based on Table Published by Commissioner of Public Roads of New Jersey

Width, feet	8	10	12	14	16	18	20
Square yards, per mile	4,693⅓	5,866⅔	7,040	8,213⅓	9,386⅔	10,560	11,733⅓
Cost per sq. yd.							
$0.25	$1,173.33	$1,466.67	$1,760.00	$2,053.33	$2,346.67	$2,640.00	$2,933.33
0.30	1,408.00	1,760.00	2,112.00	2,464.00	2,816.00	3,168.00	3,520.00
0.35	1,642.67	2,053.33	2,464.00	2,874.67	3,285.33	3,696.00	4,106.67
0.40	1,877.33	2,346.67	2,816.00	3,285.33	3,754.67	4,224.00	4,693.33
0.45	2,112.00	2,640.00	3,168.00	3,696.00	4,224.00	4,752.00	5,280.00
0.50	2,346.67	2,933.33	3,520.00	4,106.67	4,693.33	5,280.00	5,866.67
0.55	2,581.33	3,226.67	3,872.00	4,517.33	5,162.67	5,808.00	6,453.33
0.60	2,816.00	3,520.00	4,224.00	4,928.00	5,632.00	6,336.00	7,040.00
0.65	3,050.67	3,813.33	4,576.00	5,338.64	6,101.33	6,864.00	7,626.67
0.70	3,285.33	4,106.67	4,928.00	5,749.33	6,570.67	7,392.00	8,213.33
0.75	3,520.00	4,400.00	5,280.00	6,160.00	7,040.00	7,920.00	8,800.00
0.80	3,754.67	4,693.33	5,632.00	6,570.67	7,509.33	8,448.00	9,386.67
0.85	3,989.33	4,986.69	5,984.00	6,981.33	7,978.67	8,976.00	9,973.33
0.90	4,224.00	5,280.00	6,336.00	7,392.00	8,448.00	9,504.00	10,560.00
0.95	4,458.67	5,573.33	6,688.00	7,802.67	8,917.33	10,032.00	11,146.67
1.00	4,693.33	5,866.67	7,040.00	8,213.33	9,386.67	10,560.00	11,733.33
1.05	4,928.00	6,160.00	7,392.00	8,624.00	9,856.00	11,088.00	12,320.00
1.10	5,162.67	6,453.33	7,744.00	9,034.67	10,325.33	11,616.00	12,906.67
1.15	5,397.33	6,746.67	8,096.00	9,445.33	10,794.67	12,144.00	13,493.33
1.20	5,632.00	7,040.00	8,448.00	9,856.00	11,264.00	12,672.00	14,080.00

NOTE: When the cost per square yard is greater than $1.20, the corresponding cost per mile can be found by adding to the tabulated cost for a rate of $1.00 per square yard, the tabulated cost for a rate equal to the difference between the given rate and $1.00. The costs per square mile for widths greater than 20 feet are found by adding together the costs for two of the tabulated widths which will give the desired width.

The easiest method of distributing the stone is by using an automatic spreader wagon which deposits it in a layer of approximately the right thickness. The methods of determining the thickness are explained on page 295.

When a hundred feet or so of the first course has been spread, the rolling should begin. A roller weighing about 600 pounds per inch of width of roll is usually recommended for rolling hard rock, but one of three-fourths this weight will probably do better work with soft limestone. The roller starts at the edges of the stone and care should be taken that the shoulders are not crushed during the trips near the sides of the trench. The roller should not be run much faster than 100 feet per minute. After both sides are moderately firm, the roller should move gradually toward the center until the whole lower course is thoroughly compacted. The rolling should be stopped as soon as the pieces of stone begin to break. Sometimes it is found that a wavy motion continues and the stone will not compact. This may be due to a wet subgrade, which will probably give no trouble if allowed to dry for a day or two, or it may be due to the use of a very hard stone, when the application of a little sand or fine gravel may remedy the difficulty. With some soft, coarse, gravel stones a crawling motion may be noticed, which can be prevented by a light sprinkling of coarse sand, stone screenings and sometimes by water. The rolling is continued until the stone has no movement when the men walk over it. If depressions develop during the rolling they must be filled with stone of the same size as that used in the course and rolled until firm.

Some engineers advise harrowing the loose stone with a spike-tooth harrow in order to mix the stone thoroughly and to save a part of the rolling. This would be of advantage if full loads of stone were dumped directly on the subgrade, for it would break up the cores of small stone in the center of the piles. Other engineers recommend using a blade grader to shape the loose stone just before rolling.

It is not customary to apply a binder of gravel or screenings to the bottom course in some states and it is required in others. It is apparently a detail depending considerably upon the hardness of the stone used. If the stone is relatively soft and the bottom course is constructed of a large size of stone, a binder may prevent the internal disintegration of the stone under loads to some extent, but with the somewhat smaller, hard trap rock used in Massachusetts, for instance, screenings are unnecessary.

After about a hundred feet of the bottom course has been rolled, the second course is spread. This consists of the size from ½ to 1¼ or 1½ inches, and the loose depth is 3 to 5 inches. Large loads should not be dumped directly on the bottom course. The top course is usually given its final shaping with rakes. This course is rolled commencing on each outer edge with the rear wheel half on the stone and half on the shoulders; the roller is gradually worked toward the center. If depressions are developed during this work, they must be filled, and the rolling should continue until the surface is hard and uniform in contour.

The surface is then covered with the binder. The material used for this purpose varies with the character of the stone in the top course. Generally screenings are employed, but in states where the top course is composed of rather large sizes of stone the screenings have small stone mixed with them. In Maryland limestone screenings are not permitted with trap rock without the consent of the engineer. A. R. Hirst, State highway engineer of Wisconsin, advises using a clayey pea gravel or disintegrated granite with crushed quartzite or granite, and if these are unavailable he prefers a bituminous binder.

Screenings are rarely if ever permitted to be dumped on the road. They should be placed in piles along the road at such intervals that they can be distributed readily and enough material will always be available. In Massachusetts it is not customary to place the screenings to a greater depth than 1 inch. In Michigan the depth is about ¾ inch and in Wisconsin about ½ inch on State roads.

Although the screenings are sometimes rolled dry, after being spread, the usual practice is to sprinkle the road with water before rolling. The road must be sprinkled until the screenings are thoroughly wet and do not stick to the wheels of the roller. Where hard, small stone is used in the top course more water is generally employed than where the stone is larger, and an attempt is made to flush the screenings into the interstices between the stones. If the screenings are picked up by the roller at any time, more water must be applied. The sprinkling and rolling are continued until water is carried along in front of the roller wheels at every point of the road.

Rolling must be done carefully for the appearance of the road will depend upon this work.

After the road has dried sufficiently, the shoulders should be smoothed off with a road machine, if one is available. The shoulders should be trimmed so the water can flow from the center of the road to the ditches along every foot of the way. All surplus material should be removed, and the shoulders should be rolled as far out as it is safe to run the roller.

Glutrin Binder

For a number of years, glutrin has been used extensively as a binding material for both gravel and broken stone roads. It is an adhesive binding liquid whose base is the lignin derived from the sulphite pulp wood process. It is sold in a concentrated state and should be diluted with water before use.

It should be understood that when the road material to be treated is other than stone, it should contain at least 10 per cent of clay. When this is lacking in the original road material, it should be evenly added as the road material is put in place. When used on gravel or sand-clay roads, glutrin should be diluted with water in the proportion of one part glutrin to not less than three parts water. This mixture should be applied by means of any distributor which will spread it uniformly. The application should be continuous, so that the road is kept moist, but not so rapidly as to permit the forming of pools or the flowing off to the sides. Penetration must be secured, and consequently the distributor should make at least four trips over the road in applying the amount of glutrin called for in the specifications. This is usually about ½ gallon of glutrin to the square yard.

When used in the construction of broken stone or slag roads, the glutrin should be applied during the process of puddling the top course. The puddle should be begun as usual with plain water, but as soon as the screenings are thoroughly saturated, glutrin should be placed in the sprinkler in the proportion of one part glutrin to five parts water, and the puddling completed with this mixture. The specifications usually call for ½ gallon of glutrin to the square yard to be used in this process. A still stronger bond can be secured if, after the road has been puddled in this manner, it is allowed to dry out and a surface application is then made over the center 80 per cent of the width of the road, of 0.2 gallon of glutrin, diluted in the proportion of one part glutrin to three parts water. As soon as the road is dry, it can be opened to traffic.

There have been many miles of glutrin-bound roads constructed in Connecticut and New York, which have been given a bituminous top course, or even an oil treatment, the purpose being to bind the mass of stones thoroughly together with glutrin to prevent the internal disintegration of the gravel or stone by traffic and to protect the glutrin from surface water.

Glutrin should not be used with a pure siliceous material like quartz, unless at least 10 per cent of clay is added. With broken stone, the fine material produced in rolling, furnishes a substitute for the clay required with gravel.

Maintenance

Where there is very little automobile traffic the old-fashioned methods of maintenance are still applicable. If the road was built late in the fall, particularly if trap rock was used, it is possible that loose stone will appear on the surface in the spring. They should be removed and need cause no apprehension. Holes and ruts should be filled with small stone and screenings, preferably during a rain so the traffic will begin to bind the patch as soon as the weather clears. When the top course has been worn down so that the large stone of the bottom course show in places, the road should be repaired. If the top course is to be less than 3 inches thick the stone can be spread on the road and treated like the top course of a new road. If the course is to be made of 3 inches or more of loose stone, it is generally best to loosen up the road by means of spikes placed in the wheels of the roller or by the use of a scarifier.

This method of maintenance is practically obsolete on account of motor traffic. The shearing action of the wheels of an automobile on a water-bound road speedily loosens the stones of the top course and it is necessary to protect the surface by a tenacious mat of bituminous material and stone. Experience shows that this should not be applied until the road has seasoned for a few months. If the road is finished late in the fall, so that no opportunity will be afforded for it to season before winter closes down construction work, the surface can be bound with calcium chloride to hold it until spring, when the bituminous mat can be applied.

The ordinary method of maintaining the road is to clean it thoroughly and then apply a road oil uniformly over the surface. Some of these oils are so thin that they soak into the surface while others must be covered with sharp sand or screenings free from dust. The methods of doing the work are explained in the chapter on surface applications.

ROAD BUILDING ROCKS

Mineral Composition.[1]—Reports of geologists and mineralogists on road-building rocks classify them according to their origin as igneous, sedimentary and metamorphic.

Igneous rocks are those which have solidified from a very hot liquid condition and their physical condition, technically termed "structure," depends largely on the rate of cooling of the fused material. The "intrusive" or "plutonic" type of igneous rocks cooled slowly at great depths below the earth's surface, and the minerals composing it are usually in large and well developed particles. This type includes granite, syenite, diorite, gabbro, and peridotite. The "extrusive" or "volcanic" types of igneous rocks cooled more rapidly upon the earth's surface and are finer grained. They frequently show a so-called "porphyritic" structure on account of the presence of larger crystals in a fine-grained, dense mass forming the main mass of the rock. This type includes rhyolite, trachyte, andesite, basalt and diabase.

Sedimentary rocks are made up of fragments of minerals or shells that were moved about, mainly by water, and finally deposited on the beds of lakes or seas in more or less parallel layers. There they became cemented together by the pressure upon them and changes in the composition of a part of their constituents. This last change is of the same general nature as that occurring far more quickly in the case of plaster or mortar. This class includes calcareous types of rock like limestone and dolomite, and siliceous types like shale, sandstone, and chert (flint). Both types are usually distinctly bedded or stratified.

Metamorphic rocks were produced from the two classes just mentioned by pressure and heat. The long-continued shearing and compressive forces sometimes produced a "foliated" or "schistose" character, with a parallel arrangement of the minerals composing them, or a "massive" or "nonfoliated" character. Gneiss, schist and amphibolite are foliated metamorphic rocks, and slate, quartzite, eclogite and marble are nonfoliated metamorphic rocks.

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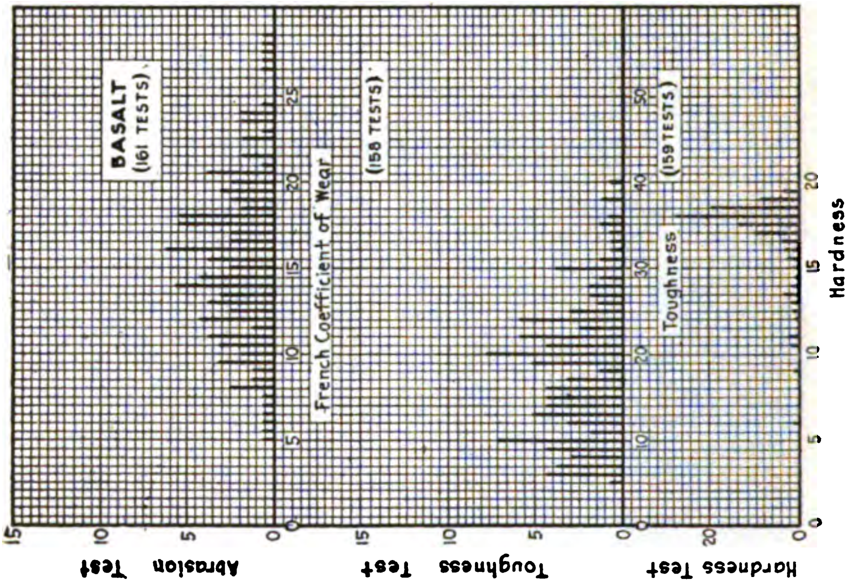
[1] Abridged from Bulletin 348, U. S. Department of Agriculture, "Relation of Mineral Composition and Rock Structure to the Physical Properties of Rock Materials," by E. C. E. Lord, petrographer, Office of Public Roads and Rural Engineering.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Hardness
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Toughness Test
Hardness Test
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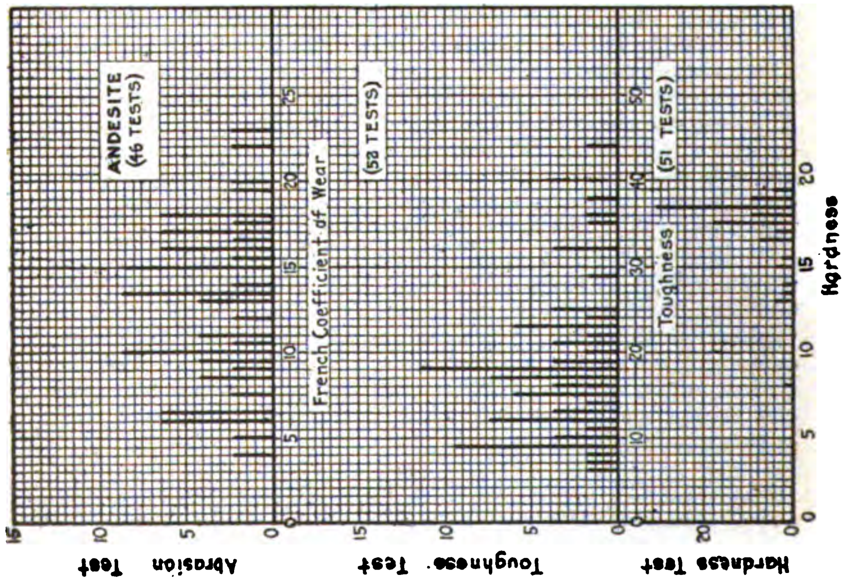
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Hardness
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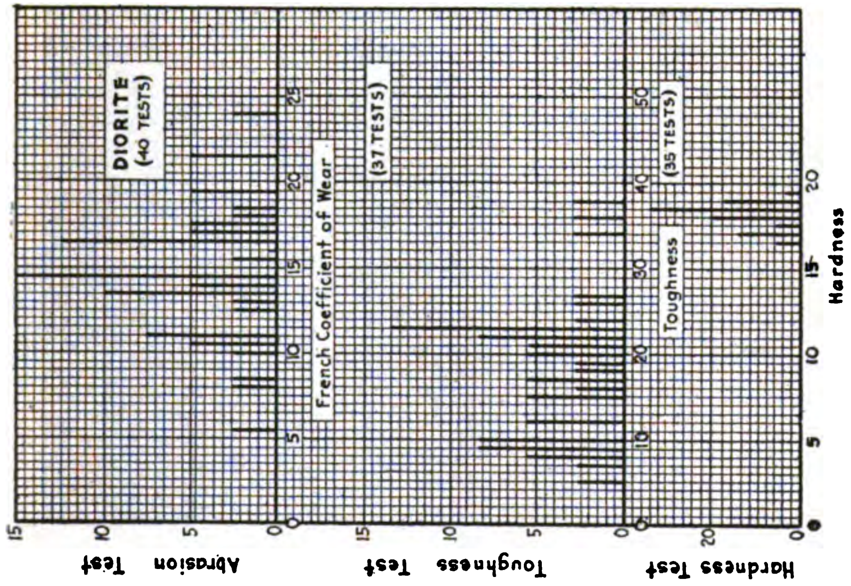
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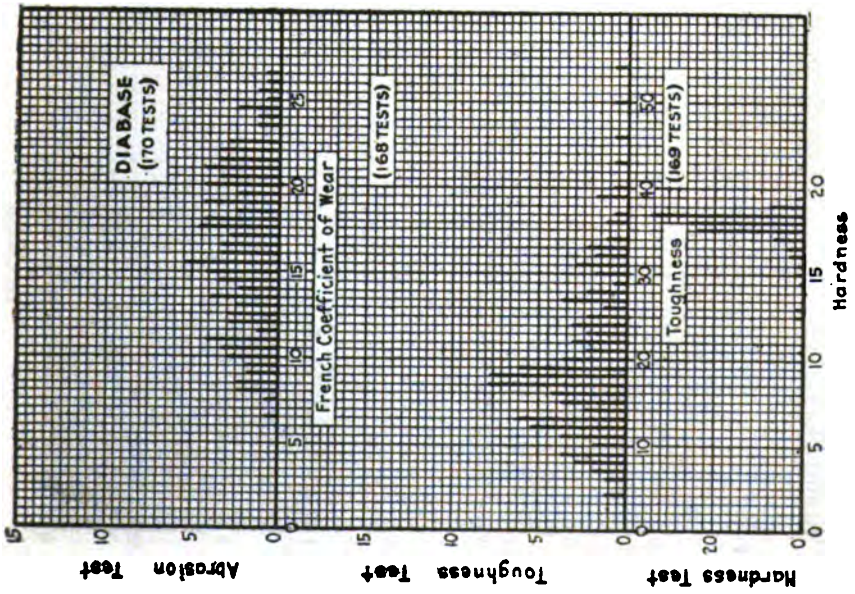
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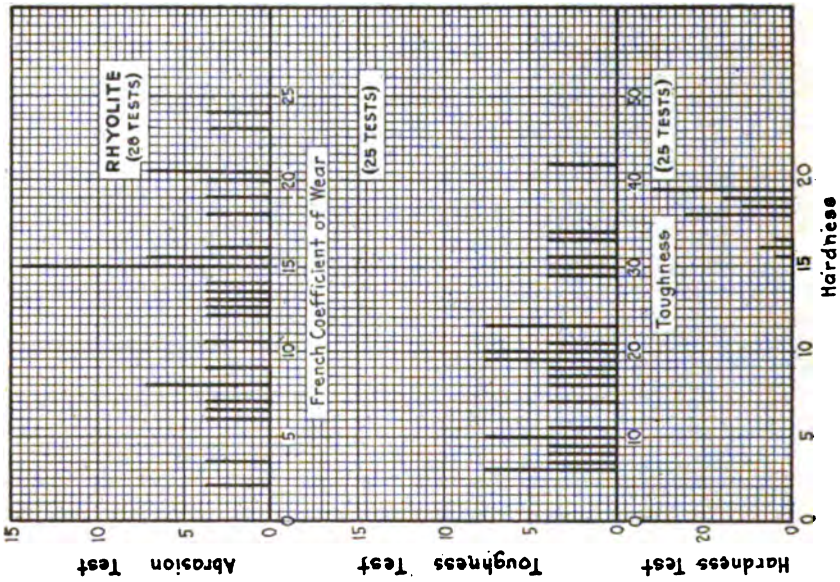
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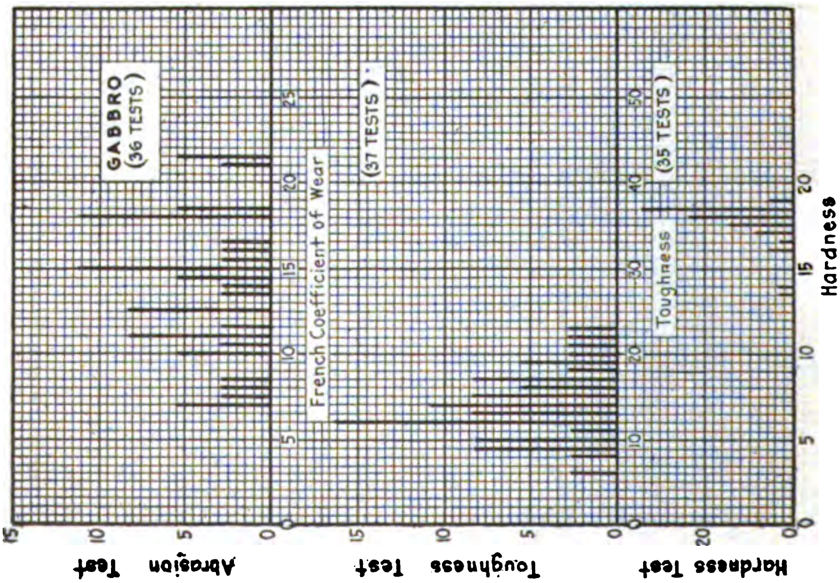
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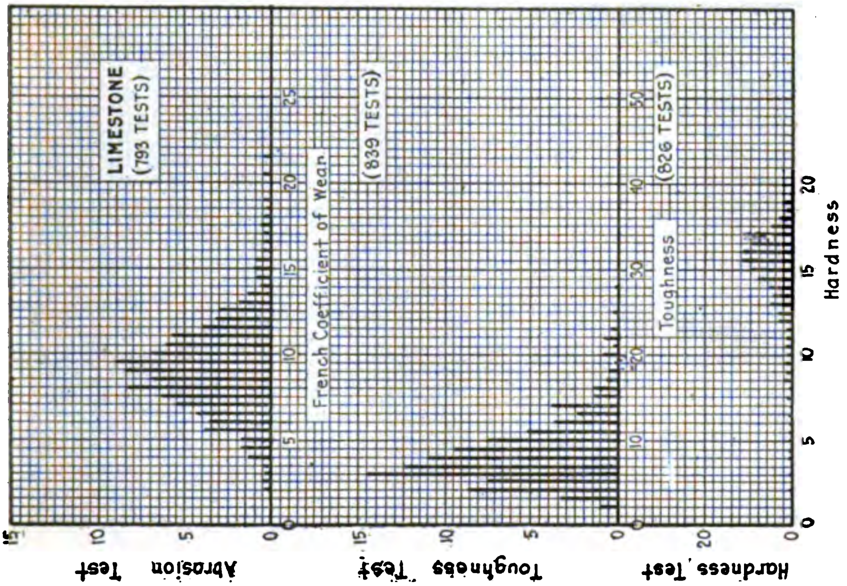
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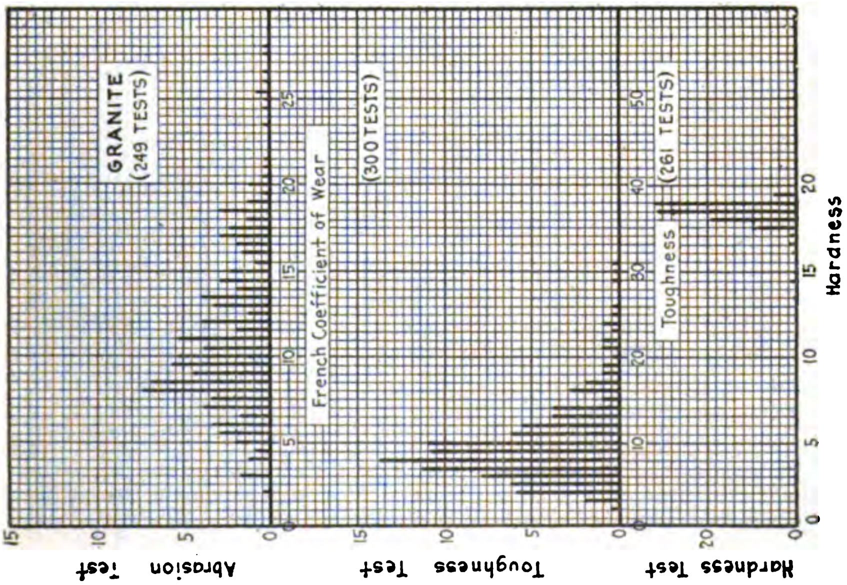
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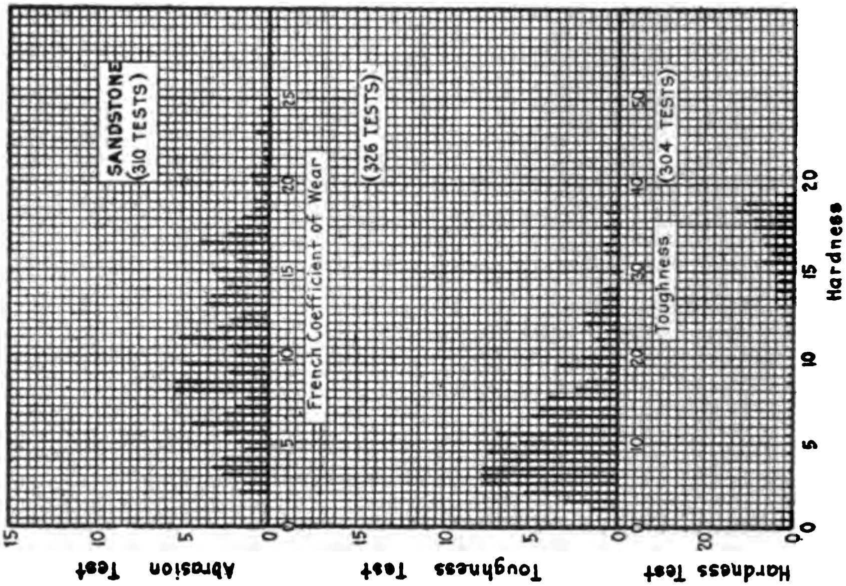
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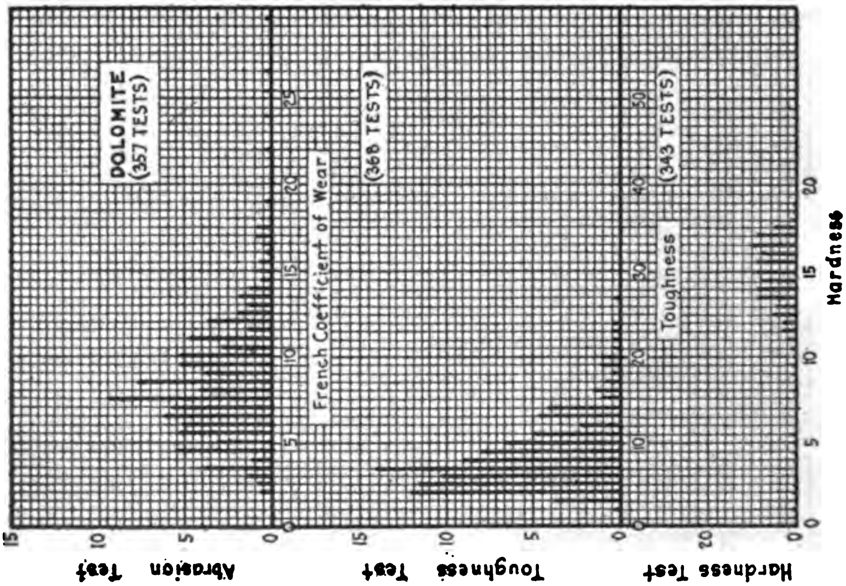
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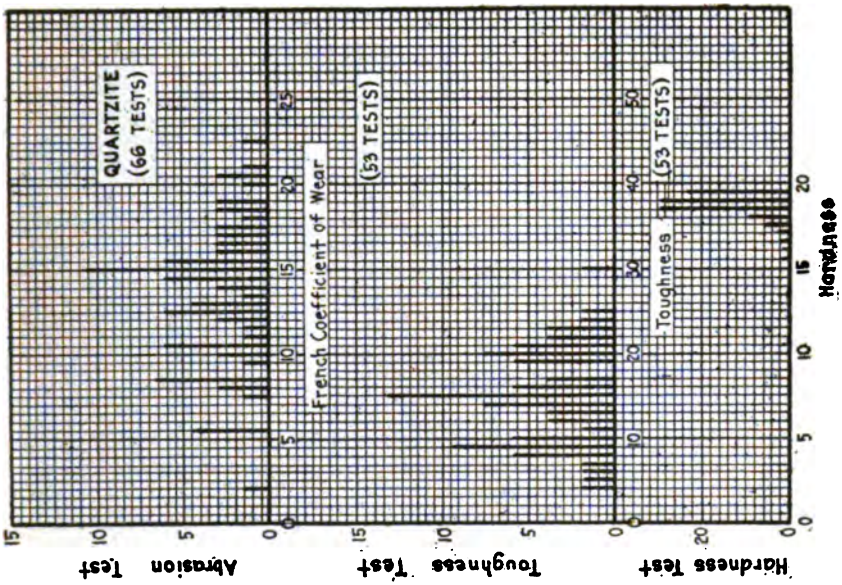
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French Coefficient of Wear
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(53 TESTS)
Toughness Test
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10
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Toughness
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(53 TESTS)
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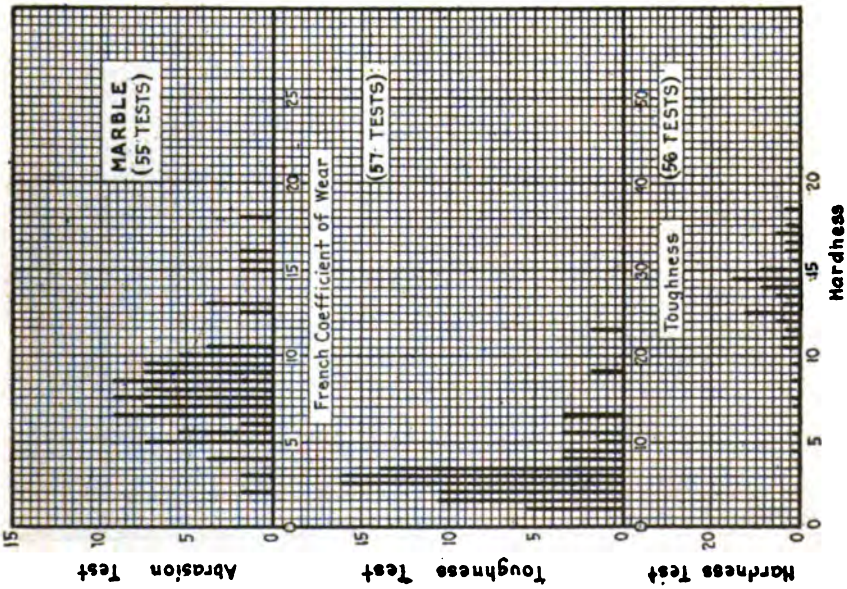
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French Coefficient of Wear
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10
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15
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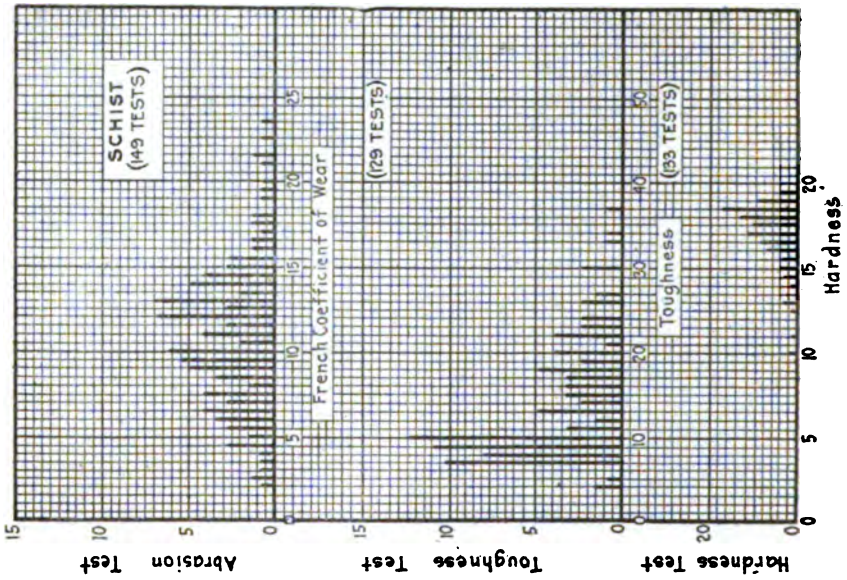
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(129 TESTS)
Toughness
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(133 TESTS)
Hardness
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Toughness Test
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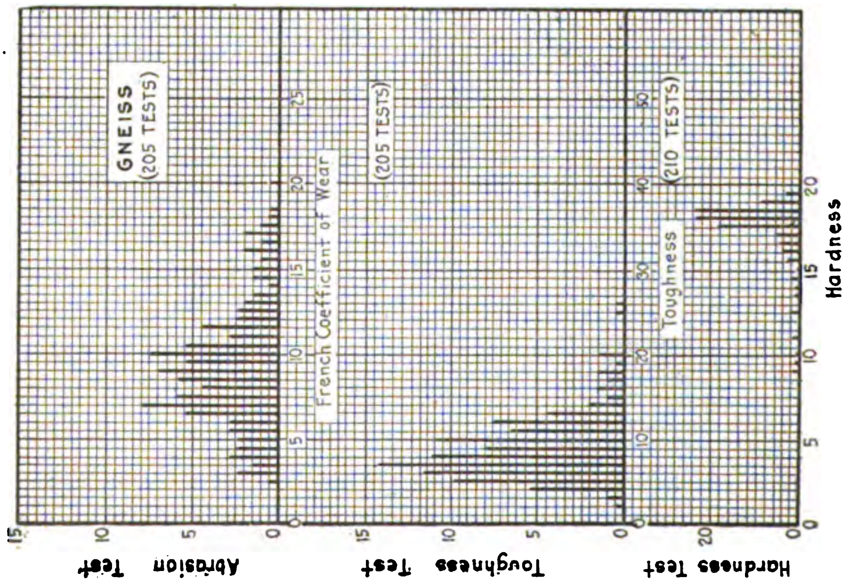
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(205 TESTS)
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(210 TESTS)
Hardness
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10
15
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Abrasion Test
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Toughness Test
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Hardness Test
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The original mineral components of igneous rocks and the essential part of metamorphic schists are quartz, plagioclase, orthoclase, augite, hornblende, muscovite, biotite, rock glass, magnetite and garnet. These are called primary minerals. Rock glass, included among them, is a mineral of variable composition found in certain volcanic rocks which cooled very rapidly. It is extremely brittle and when present in appreciable quantities has a tendency to lower the wearing properties of the rock. Orthoclase and plagioclase are usually called "feldspar" by engineers and biotite and muscovite are called "mica."

Quartz is the most widely distributed mineral known. It has a specific gravity of 2.66 and a hardness of 7 in Mohs' scale.[1] When present in large quantities, especially when finely consolidated, as in fine-grained, igneous and massive metamorphic rocks, the resulting material is extremely hard and offers great resistance to wear.

Orthoclase and plagioclase are among the principal ingredients of igneous and metamorphic rocks and some sandstones. Their specific gravity is 2.54 to 2.76 and their hardness 6 to 6.5. Many coarse-grained feldspathic rocks break down readily under impact on account of the cleavage of these minerals. In fine-grained rocks the effect of this cleavage is less marked, and some of them are extremely hard and tough.

Augite and hornblende are the chief iron-bearing or dark silicate constituents of basic igneous rocks, commonly called "trap rocks," and the crystalline schists derived from them. Their specific gravity is 2.93 to 3.71 and their hardness 5 to 6.5. Their crystalline shape is such that they interlock very compactly with other minerals, which is one of the reasons for the marked durability of trap rocks.

Biotite and muscovite occur chiefly in granite, gneiss and micaceous schist. Their specific gravity is 2.7 to 3.2 and their hardness is 2 to 3. The flaky character of mica is well known and is largely responsible for the foliated character of many metamorphic rocks and their resulting inferior wearing properties in roads.

Magnetite has a specific gravity of 5.18 and a hardness of 5.5. Garnet has a specific gravity of 3.15 and a hardness of 7.5. They occur in only two road-building rocks, peridotite and eclogite, and in some cases materially increase the wearing properties of the rock.

Secondary minerals are produced by the alteration of rocks, mainly by the chemical action of water and carbonic acid on primary rock constituents. The chief secondary minerals are calcite, dolomite, kaolin, chlorite, epidote, limonite, serpentine, talc, zeolite and opal.

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[1] Mohs' scale of the relative hardness of minerals is as follows: 1, Talc; 2, gypsum; 3, calcite; 4, fluorite; 5, apatite; 6, orthoclase; 7, quartz; 8, topaz; 9, corundum; 10, diamond.

Calcite has a specific gravity of 2.6 and a hardness of 3. Dolomite has a specific gravity of 2.9 and a hardness of 3.5. These two minerals are the chief constituents of limestones and dolomites, and cannot be distinguished microscopically. They cleave freely and hence many calcareous rocks break down readily when used in roads.

Kaolin is derived to a large extent through the decomposition of orthoclase. It sometimes occurs in small crystal flakes resembling white mica (muscovite), and sometimes as minute grains of very indefinite composition. In the latter form, called "amorphous," kaolin has a great effect on the binding property of rock powders, for it becomes glue-like when wet, and when dry it binds together firmly the other mineral particles with which it is associated.

Chlorite and epidote are derived from augite, hornblende, biotite and plagioclase and are most abundant in trap rocks and dark crystalline schists. Chlorite is a soft green mineral which occurs either in mica-like flakes or as very fine scales and fibers of indefinite composition. In the latter form it has cementing properties like those of amorphous kaolin. Epidote (specific gravity, 3.25–3.5; hardness, 6–7) occurs as yellowish green crystals which, when present in appreciable quantities, apparently increase the wearing properties of rocks.

The results of a study of several hundred road-building rocks indicate that the effects of their mineral composition on their value for highway purposes are probably as follows:

Igneous and nonfoliated metamorphic rocks, owing to a preponderance of hard silicate minerals combined with greater uniformity in structure, are more durable than other road-making materials, finer-grained varieties offering greater resistance to abrasion than coarse-grained types.

The resistance to wear of igneous and metamorphic rocks, containing an abundance of quartz, hornblende, augite, epidote, and garnet, is greater than that of similar rocks rich in mica, chlorite, serpentine, and calcite.

Foliated metamorphic rocks, owing to the parallel arrangement of their mineral constituents, are, as a rule, deficient in toughness and therefore not well adapted to road construction.

Sedimentary rocks are usually deficient in wearing properties, except in the case of highly indurated sandstones, containing a moderate amount of siliceous clay, cement, and limestones or dolomites rich in quartz and having very little clay.

Rocks for road making break down under impact into fragments, the shape and physical character of which are conditioned by mineral composition and structure.

The effect of weathering is generally to lower the resistance to wear of road materials, owing to the development of soft, in part glue-like (colloidal) products of alteration. Where the secondary minerals are harder and more crystalline the wearing properties of the rocks are proportionately increased.

The cementing value of road materials is conditioned chiefly by the glue-like (colloidal) products of rock decay and increases in a general way proportionately with these products, reaching a maximum in rocks free from quartz.

The slaking property of rock powders is dependent in the case of siliceous igneous and metamorphic rocks chiefly on the physical character of the primary mineral components, whereas in basic igneous rocks and sandstones it is caused to a large degree by glue-like (colloidal) products of rock decomposition.

Physical Properties.[1]—The success or failure of a rock for road building depends largely upon the extent to which it will resist the destructive influences of traffic. The three most important physical properties are hardness, toughness, and binding power. Hardness is the resistance which the rock offers to the displacement of its surface particles by abrasion; toughness is the resistance which it offers to fracture under impact; and binding power is the ability which the dust from the rock possesses, or develops by contact with water, of binding the large rock fragments together. In order to approximate as closely as possible in the laboratory the destructive effects produced by traffic, climatic agencies and faulty construction, certain physical tests have been developed.

Hardness is determined by subjecting a cylindrical rock core 25 millimeters in diameter, drilled from the specimen to be examined, to the abrasive action of quartz sand fed upon a revolving steel disk. The end of the specimen is worn away in inverse ratio to its hardness, and the amount of loss is expressed in the form of a coefficient as follows:

Coefficient of hardness $= 20 - w/3$, where w equals the loss in weight after 1,000 revolutions of the disk.

Toughness is determined by subjecting a cylindrical test specimen 25 by 25 millimeters in size to the impact produced by the fall of a 2-kilogram hammer upon a steel plunger whose lower end is spherical and rests upon the test piece. The energy of the blow delivered is increased by increasing the height of fall of the hammer 1 centimeter after each blow. The height of blow in centimeters at failure of the specimen is called the toughness.

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[1] Abstracted from Bulletin 370, U. S. Department of Agriculture, "Results of Physical Tests of Road Building Rock," by Prévost Hubbard, chemical engineer, and Frank H. Jackson, Jr., assistant chemical engineer, Office of Public Roads.

A test devised by the French and sometimes called the Deval test, for measuring the combined action of abrasion and impact, is as follows: Five kilograms of freshly broken rock between 2 and 2½ inches in size is tested in a special form of cylinder so mounted on a frame that the axis of rotation of the cylinder is inclined at an angle of 30° with the axis of the cylinder itself. The fragments of rock forming the charge are thus thrown from end to end twice during each revolution, causing them to strike and rub against each other and the sides of the cylinder. After 10,000 revolutions the resulting material is screened through a $\frac{1}{16}$-inch sieve and the weight of the material passing is used to calculate the percentage of wear. The French coefficient of wear is calculated from the per cent of wear as follows:

$$\text{French coefficient of wear} = 40 \div \text{percentage of wear}$$

To determine the binding power, or cementing value, as it is usually called, 500 grams of the material to be tested is crushed to pea size and ground with water in a ball mill until it has the consistency of a stiff dough. It is then molded into cylindrical briquettes 25 by 25 millimeters in size, which, after thorough drying, are tested to destruction in a special form of impact machine. A 1-kilogram hammer falls through a constant height of 1 centimeter upon an intervening plunger, which in turn rests upon the test piece. A graphic record of the number of blows required to destroy the specimen is obtained. The number of blows producing failure is called the cementing value of the material.

The specific gravity, weight per cubic foot, and the water absorption in pounds per cubic foot are obtained on samples of rock which are tested to determine their road-building qualities. The weight per cubic foot is calculated from the specific gravity of the material obtained on a 10-gram sample by the usual displacement method. The gain in weight of this fragment after four days' continuous immersion in water is used to calculate the water absorption in pounds per cubic foot of the solid rock.

Results of Tests.—Because of the fact that the various rock families, when subjected to the tests outlined, give results which are more or less distinctive of a group or type, these results can best be discussed in many cases collectively. There are 14 families of rock which are more or less commonly used in macadam-road construction. The variations which have been found to exist in the three principal tests for each of these are shown in graphic form in the diagrams on pages 314–320. The values of the tests are arranged as abscissæ, with the zero points to the left and the values numerically increasing toward the right.

The ordinates or vertical lines represent the percentages of the total number of samples having values corresponding to the abscissæ on which they are plotted. The figures in parentheses in the upper right-hand corner of each block represent the total number of determinations from which these percentages were calculated.

Andesite, Basalt, Diabase, Diorite, Gabbro, and Rhyolite comprise the well-known group of road-building rocks commonly known as "trap." The average toughness of all the traps, with the exception of gabbro, which runs somewhat lower, is about 18. This is a considerably higher average than that shown by any of the other types or groups. The same relationship holds true in the abrasion test, the average French coefficient of wear running from about 13 to 15. Comparatively slight variations in hardness are noted for any family or for the group as a whole, the average hardness for which is about 18. The binding power of the traps varies through wide limits, depending largely on the degree of weathering they have undergone. The specific gravity of this group averages about 2.9, giving an average weight per cubic foot of 180 pounds. Individual samples are seldom less than 2.7 nor more than 3.2 specific gravity. Water absorption may vary from a few hundredths of 1 per cent to over 7 per cent.

Granite is characterized by low toughness and high hardness. The average value for the former is about 8, while that for the latter runs as 18.5. The abrasion test develops an average French coefficient of wear of about 11. Cementing values run low, the only exceptions being very highly weathered material which usually shows low toughness and resistance to wear. The specific gravity averages 2.7. The weight per cubic foot averages 168 pounds. Water absorption has been found to run from about 0.04 to 3 per cent.

The limestones and dolomites, or magnesium limestones, are undoubtedly the most widely used road-building rock. The average French coefficient of wear is about 8, toughness 7, and hardness 15. The cementing values are usually good, about 75 per cent of all samples tested running over 25. The specific gravity of the limestones and dolomites averages close to 2.7. In general, the weight per cubic foot will average about 168 pounds for the limestones and 170 pounds for the dolomite. Absorption may vary from a few hundredths of 1 per cent to over 13 per cent.

The sandstones are characterized by wide variations in the results of all tests. The average French coefficient of wear is about 12, average toughness about 10, and average hardness about 16. The cementing value of sandstones varies widely, depending upon their composition. Their specific gravity averages 2.62. The weight per cubic foot averages 164 pounds. Absorption runs from a few hundredths of 1 per cent to about 2 per cent.

The average toughness of marble is about 5 and the average hardness is less than 14. Marbles usually show good cementing value tests, with about the same range as the limestones and dolomites. The specific gravity ordinarily falls between 2.7 and 2.9 and the weight per cubic foot averages 173 pounds, which is somewhat higher than the average for either limestone or dolomite. The maximum absorption is under 2.5 per cent.

Quartzites show an average toughness of 15. The quartzites invariably show a low cementing value. Their specific gravity usually lies between 2.6 and 2.8 and their average weight per cubic foot is about 167 pounds. Their water absorption runs from a few hundredths of 1 per cent to nearly 3 per cent.

Gneiss and schist show similar physical properties. The average French coefficient of wear for the gneiss samples is about 9. Their average hardness, toughness, specific gravity, weight per cubic foot, and absorption are approximately the same as for granite.

The schists show an average French coefficient of wear of about 12. Their average hardness is about 17.5 and their toughness averages 11. The toughness test for both gneiss and schist is made perpendicular to the plane of foliation. If taken horizontal to the plane of foliation much lower results would be obtained, as failure would then occur along these natural lines of cleavage. The specific gravity of schists usually lies between 2.65 and 2.90 and the average weight per cubic foot is about 181 pounds. Water absorption is seldom over 2 per cent for this family.

With the exception of the highly altered varieties, both gneisses and scists show a rather low cementing value.

Chert is a very hard material, but frequently shows a low resistance to wear, owing to its tendency to fracture along lines which have developed as shrinkage cracks in the rock structure. For this reason it is extremely difficult to test for toughness. The cementing value of pure chert is usually low, but some highly weathered deposits develop in service good cementing value, especially if a high-binding clay is associated with it. The French coefficient of wear has usually been found to average 5, toughness 16, and the hardness coefficient between 19 and 20. Specific gravity usually lies between 2.4 and 2.65 and the average weight per cubic foot is about 160 pounds. Water absorption may run from a few tenths of 1 per cent to over 8 per cent.

Shales and slates are highly laminated rocks that tend to break into flat plates not suitable for road-building purposes. They are seldom used in road construction, except perhaps as a filling for sub-foundations. They vary greatly in nearly all of their physical properties.

Many varieties of slag resemble in certain outward respects the common road-building rocks. However, in general, they are more porous and glassy, and vary so greatly in physical properties that with reference to their physical characteristics from the standpoint of road construction they cannot well be considered as a single class with definite limits or general average numerical values.

CONCRETE ROADS

Although concrete pavements were laid at Bellefontaine, Ohio, in 1893 and 1894, the type did not attract general attention until fifteen years later. During 1913, over 10,000,000 square yards were laid, eight times as much as in 1911. This rapid development was accompanied by marked differences in methods of construction, which aroused some apprehension that poor results from inferior methods would retard the logical adoption of the type in places for which it was suited. Accordingly road and street engineers and contractors from all parts of the country met in February, 1914, for a three-day discussion of concrete road building. The report of this conference exercised a standardizing influence on methods of construction, as had the somewhat earlier adoption by the American Concrete Institute of standard specifications for concrete roads and pavements. Some of the methods of construction presented features which required detailed investigation, and committees were appointed for such work. In February, 1916, a second national conference was held, at which the reports of these committees were received and discussed. This chapter summarizes the information presented at that conference.

Foundation and Subgrade

The following opinions regarding foundations and subgrade were adopted by the 1916 conference:

> When roadways are constructed over fills, extreme care should be observed to insure the use of proper materials in layers of such thickness that they may be thoroughly compacted so that when the fill is completed there will be a minimum of settlement. In general, fills shall be made in thin layers, the depth depending on the character of material to be used in making the fill. The fill should be allowed to stand for as long a time as possible, giving it an opportunity to settle thoroughly before the pavement is placed thereon. Deep fills should be allowed to settle through one winter wherever such procedure is possible. Puddling will be found advantageous in compacting deep fills. Wetting and rolling shall be performed when making a fill in order to secure thorough compactness. Fills should never be made with frozen materials nor with lumps greater than 6 inches in their greatest dimension.
>
> The fundamental requirement of the subgrade is that it should be of uniform density so that it will not settle unevenly and cause cracks in the surface of the pavement. No part of the work is more worthy of intelli-

> gent care and painstaking labor than the preparation of the subgrade. The slight additional cost necessary to insure good results is abundantly justifiable. When the pavement is constructed on virgin soil, care should be taken to remove all soft spots so as to insure a uniform density; and if constructed on an old roadbed, even greater care must be taken to secure uniform density, as the subgrade is likely to be more compact in the center than at the sides. An old roadbed should be scarified, reshaped and rolled. The subgrade adjacent to curbs should be hand-tamped.

The importance of a uniformly firm support for the concrete slab was not fully appreciated by all roadbuilders. There was an opinion among some that the concrete would act as a beam and distribute the loads coming on it over such a wide area that inequalities in the sustaining power of the earth would prove unimportant. The number of cracks in concrete pavements attributable to unwarranted confidence in this beam action is beyond proof, but today the opinion is generally held that the money spent in securing a firm foundation is a wise outlay to insure low maintenance charges. This is particularly the case where an old road is used for a foundation. It is unlikely that a concrete pavement will be laid on it until the old road needs repairs. If the surface is then merely leveled by a thin course of stone or gravel, it is possible that there will be weak places, particularly along the sides of the road.

Drainage

The 1916 conference adopted the following statement of the principles which should govern the drainage of the roadbed supporting a concrete slab:

> The drainage of the roadbed is of vital importance. If the subgrade is not well drained there is danger of unequal settlement and of frost action, which will cause cracks. The method of drainage to be used will depend on local conditions. For streets, as well as roads, tile drains may be used which should be laid on each side of the roadway, or on one side only, with cross-drains leading thereto at a suitable depth, depending on the width of the pavement. Drainage trenches, if placed under the subgrade, should be completed before final rolling.

There is an objection to the use of cross-drains under thin concrete roads which is not serious in most cases but may be under some conditions. It is practically impossible to compact the material over a blind drain as thoroughly as that of the main portion of the subgrade, and each blind drain is likely to be a weak place in the foundation. An alternative for them which some engineers have advised is the construction of a blind drain just outside each edge of the concrete slab and extending 8 or 10 inches below the subgrade. These drains are connected every 50 feet with the side ditches by blind drains. All drains under the roadway should have a covering of sand or fine gravel on top to prevent the mortar in the wet concrete from passing into the broken stone or gravel of the drain.

Cross-section of Roads

The following statements were adopted by the 1916 conference regarding the section of the concrete pavement:

> The thickness of a concrete road or pavement is controlled by many factors, each of which should be given consideration. In view of the increasing use of the heavy motor truck and bus, it seems unwise to build pavements with a thickness of less than six inches at any point. In general, pavements should be thicker at the center than at the sides. Alleys with an inverted crown, and narrow one-slope roads, should have a uniform thickness. Wherever the thickness can be increased without excessive cost, to secure a flat subgrade, or one nearly flat, such increase is advisable.
>
> The desirable width for single-track roads is 10 feet. The desirable width of double-track roads is 18 feet. The total width of the roadway should not be less than 20 feet for single-track roads and not less than 26 feet for double-track roads.
>
> The crown of roads and pavements should be not less than one one-hundredth nor more than one-fiftieth of the total width. Except in unusual cases, one one-hundredth will be sufficient for country roads and one-fiftieth will be considered satisfactory for alley pavenents. For city streets an average crown of one-seventy-fifth will generally be found sufficient and should not be reduced, except on grades.

Single-track concrete roads are occasionally built on the right-hand side of the roadway going in the direction of the heavy traffic. This gives the loaded wagons the better surface. The templet used in determining the section of the road is the same as for a double-track road but only one-half the road is concreted. In Huron and Medina Counties, single-track roads have been built as one-slope roads instead of half the section of double-track roads, and this construction is preferred by some engineers.

In Wayne County, Michigan, it has been decided to make concrete roads 18 feet wide wherever possible, and never less than 16 feet. Near Detroit the width will be 20 feet. While this increase in width from 10,' 12, 15, and 16 feet will add materially to the first cost, it is expected to prove economical in the long run, because the expense of maintaining heavy broken stone or gravel shoulders will be avoided. This maintenance is a large sum on comparatively narrow roads with heavy traffic.

There is a decided difference of opinion regarding shoulders for concrete roads. Some engineers hold that the natural soil should be used, and where satisfactory shoulders cannot be made of it the width of the concrete should be increased. Other engineers recommend gravel or broken stone shoulders after experience with them. The difference of opinion is probably due to differences in the quality of the earth which must be used for earth shoulders and to differences in the character of the traffic, upon which the opinions are based. There is no question, however, that if traffic makes frequent use of shoulders of clay or clayey loam, they are speedily ruined, and if heavy traffic makes frequent use of macadam shoulders, the junction between the concrete and broken stone becomes a long rut. In either case the proper maintenance of the shoulders will be expensive. If two macadam or gravel shoulders wider than 4 feet are considered necessary, it is advisable in every case to consider the alternative of an increased width of concrete. The construction of gravel and macadam shoulders should be postponed, if practicable, until a month after the concrete road has been finished, and they should be left slightly higher than the concrete to facilitate turning out on them.

In cuts, where the grades are over 5 per cent, it is usually necessary to pave the ditches and to use gravel or macadam shoulders. The maintenance of these ditches and shoulders is expensive, and it is possible that money will be saved in the end, even on single-track roads, by increasing the width of the concrete and adding a concrete ditch and curb at each side. The ordinary construction will call for a 10-foot concrete road, 8 feet of shoulders and 8 feet of ditches, a total of 26 feet width of cut at the bottom of the excavation. For this can be substituted a concrete roadway 16 feet wide with two integral curbs bringing the total width to 17 feet 8 inches. The curb acts as an abutment for the toe of the slope.

On fills over 5 or 6 feet high, where turning out on a soft shoulder may cause a serious accident, it is desirable to widen a single-track pavement to 16 feet unless the top of the fill is so wide that an overturned car will not roll down the slope. In any such case, the safety of the public requires a more careful study of the dangers on embankments than was given to the subject before automobiles became numerous. Attention is called to the record of deaths and injuries on page 246.

Materials

Cement is bought for most road work under the standard specifications of the American Society for Testing Materials, which were revised in 1916. They are printed in the next chapter.

The following statements regarding fine and coarse aggregate were adopted by the 1916 conference:

The selection of proper aggregates for concrete road construction is of utmost importance. Clean, hard, well-graded materials are absolutely essential to success. For this reason samples of the materials proposed for use should be submitted to the engineer for approval before orders are placed. These samples should be carefully inspected; and if possible laboratory tests made to determine their suitability. If laboratory tests on shipments cannot be made, field tests can be used to furnish a general indication of quality.

The different aggregates should be kept clean and separate.

Aggregates to be used in the wearing course of two-course pavements should never be placed on the subgrade but on planks or some other means provided to keep them free from dirt. When aggregates are placed directly on the subgrade care should be used by the shovelers to avoid getting clay or earth shoveled from the subgrade into the mix. Aggregates should not only be clean when they are delivered on the job, but clean when placed in the mixer.

Investigations to determine the usefulness of the rattler test to show the value of different concrete mixtures for road work indicate that it may prove of value. For the present, however, the older practice of relying on tests of the stone is being followed wherever any testing is done. Generally the best clean, hard and tough crushed rock or gravel is used, provided it will give a concrete harder than the mortar used with it. It is desirable to use stone having a French coefficient of wear of at least 8.

Experience indicates that cracks occur more often in gravel concrete than in stone concrete. Probably this is largely due to the very fine material on the surface of most gravel pebbles, which must be washed off carefully to make the material fit for road work.

Fine aggregate, or "sand," is generally required to pass a ¼-inch screen. Not more than 25 per cent must pass a 50-mesh sieve and not more than 5 per cent a 100-mesh sieve. It must contain no vegetable or other deleterious matter and not over 3 per cent by weight of clay or loam. The sand should be tested frequently in the field by shaking a sample with water in a graduated glass and allowing it to settle for an hour. If there is more than about 5 per cent of very fine material showing on the top of the sand, samples should be sent to the laboratory. Natural sand or screenings from hard, tough, durable rock may be used. Natural sand sometimes contains vegetable acids which reduce its value for good concrete. Their presence is determined by making similar briquettes of the natural sand and of standard Ottawa sand, and no natural sand should be used in road work which does not give a strength at least equal to that obtained with Ottawa sand. The best sand is that in which the coarse particles predominate. Improvements can sometimes be made by mixing two natural sands or a fine sand and screenings.

The standard specifications for coarse aggregate, or "stone" call for material passing a 2-inch round opening, with not more than 5 per cent passing a screen having four meshes per inch and without any intermediate sizes removed.

The water used in making the concrete must be free from oil, acid, alkali or vegetable matter.

Proportions

The 1916 conference adopted the following statements of the principles governing the proportions of the materials:

> The method of measuring materials for the concrete, including water, should be one which will insure accurate proportions of each of the ingredients at all times. It is recommended that a sack of Portland cement, containing 94 pounds net, be considered the equivalent to 1 cubic foot.
>
> The proportions should not exceed 5 parts of fine and coarse aggregate measured separately to 1 part of Portland cement, and the fine aggregate should not exceed 40 per cent of the mixture of fine and coarse aggregates.

The standard specifications for one-course country roads call for one sack of cement to not more than 2 cubic feet of fine aggregate and not more than 3 cubic feet of coarse aggregate, with the volume of fine aggregate never less than half that of the coarse aggregate. A cubic yard of the mixed concrete must contain at least 1.7 barrels of cement. The amount of water used must be enough to produce concrete holding its shape when struck with a template. Concrete which has partly hardened must never be used.

The standard specifications for two-course pavements call for a base mixed in the proportions of 1 sack of cement to not more than 2½ cubic feet of fine aggregate and not more than 4 cubic feet of coarse aggregate, with at least half as much fine as coarse aggregate. Two grades of top aggregate are specified for the top course; No. 1 must pass a ½-inch screen and have not over 10 per cent passing a ¼-inch screen, and No. 2 must pass a 1-inch screen and have not over 5 per cent passing a ¼-inch screen. Two mixtures are specified for the top course. Mixture 1 consists of one sack of cement to not more than 1 cubic foot of fine aggregate and not more than 1½-cubic feet of No. 1 top aggregate. Mixture 2 consists of one sack of cement to not more than 1½ cubic feet of fine aggregate and not more than 2½ cubic feet of No. 2 top aggregate. The volume of fine aggregate must equal half the volume of top aggregate in either mixture.

The quantities of cement, sand and gravel required to build a mile of road of different widths and thicknesses are given in the accompanying tables, supplied by the Portland Cement Association. They are based on the assumption that a barrel of cement is equivalent to 4 cubic feet and the voids in the stone are 45 per cent. Variations from the tabulated quantities may amount to 10 per cent either way.

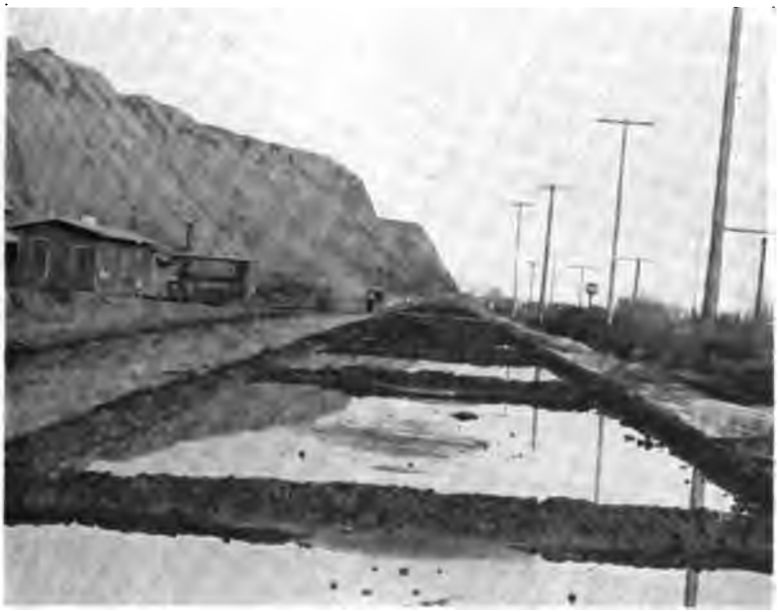
The proportions of cement, sand and stone should be such that the concrete will have the properties desired for a road. Where good stone is expensive but softer stone is cheaper, a two-course pavement utilizing the poor stone in the base and the hard stone in the top may prove more economical than a thinner one-course pavement of the harder stone. In any case the amount of mortar used should be about 10 per cent in excess of the voids in the stone. There is so much variation in the grading of sand and stone that a 1 : 2 : 4 mixture in one place may be equal to a 1 : 2 : 3 mixture in another. As the work progresses, the quality of the concrete must be watched carefully, and the proportions shifted so that the greatest density will be obtained. Attention to this feature of the work is considered very important by experienced concrete road builders.

Quantities of Cement, Sand and Stone Required for One Mile of Single-Course Concrete Road of Different Widths and Thicknesses

(Furnished by the Portland Cement Association)

WIDTH	THICKNESS		AREA CROSS SECTION	SUPERFICIAL AREA	VOLUME CONCRETE	MIX; 1: 2: 4			MIX; 1: 2: 3			MIX; 1: 1½: 3		
	Side	Center				Cement	Sand	Stone	Cement	Sand	Stone	Cement	Sand	Stone
ft.	*ins.*	*ins.*	*sq. yds.*	*sq. yds.*	*cu. yds.*	*bbls.*	*cu. yds.*	*cu. yds.*	*bbls.*	*cu. yds.*	*cu. yds.*	*bbls.*	*cu. yds.*	*cu. yds.*
10	5	6¼	0.540	5,867	951	1436	428	856	1654	494	732	1818	405	809
10	6	7¼	0.633	5,867	1113	1680	496	991	1938	578	856	2124	473	946
12	5	6½	0.667	7,040	1173	1771	521	1043	2040	610	903	2240	498	997
12	6	7½	0.778	7,040	1369	2067	608	1218	2382	710	1054	2614	582	1164
14	5	6¾	0.799	8,213	1407	2125	625	1250	2448	732	1084	2685	597	1195
14	5	7	0.821	8,213	1445	2182	650	1298	2514	751	1113	2760	607	1228
14	6	7¾	0.929	8,213	1635	2469	728	1455	2845	850	1259	3121	695	1390
14	6	8	0.951	8,213	1673	2526	753	1504	2911	870	1288	3195	703	1422
16	5	7	0.938	9,387	1651	2493	735	1469	2873	859	1271	3153	702	1403
16	6	8	1.086	9,387	1912	2887	851	1702	3327	994	1472	3652	813	1625
18	5	7¼	1.083	10,560	1907	2880	849	1697	3318	992	1468	3642	810	1621
18	6	8¼	1.250	10,560	2200	3322	979	1958	3828	1144	1694	4202	935	1870
20	5	7½	1.235	11,733	2173	3281	967	1934	3781	1130	1673	4150	924	1847
20	6	8½	1.420	11,733	2499	3773	1112	2224	4348	1300	1924	4773	1062	2124
22	5	5	1.019	12,907	1794	2709	798	1597	3122	933	1381	3426	762	1525
22	6	6	1.222	12,907	2151	3248	957	1914	3743	1119	1656	4108	914	1828
24	5	5	1.111	14,080	1955	2952	870	1740	3402	1017	1505	3734	831	1662
24	6	6	1.333	14,080	2346	3543	1044	2088	4082	1220	1806	4482	997	1994
30	5	5	1.389	17,600	2444	3690	1087	2175	4253	1271	1882	4670	1038	2077
30	6	6	1.667	17,600	2934	4430	1305	2611	5105	1526	2259	5603	1247	2494

Building a Concrete Road in Ohio



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The Baker Finishing Machine For Concrete Roads

When it passes over the concrete it not only leaves a perfect crown but forces out all bubbles of air and excess water. A vibrating and compressing pan tamps the concrete, producing a smooth, hard wearing surface.

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We began making concrete mixers twenty years ago and started at the same time a definite service policy. That policy was to make sure the mixer was "right"; it began long before the mixer was sold and lasted until it had done its work. The same policy has been maintained ever since it was started, with the result that 62 per cent of our orders last year were from old Foote users.

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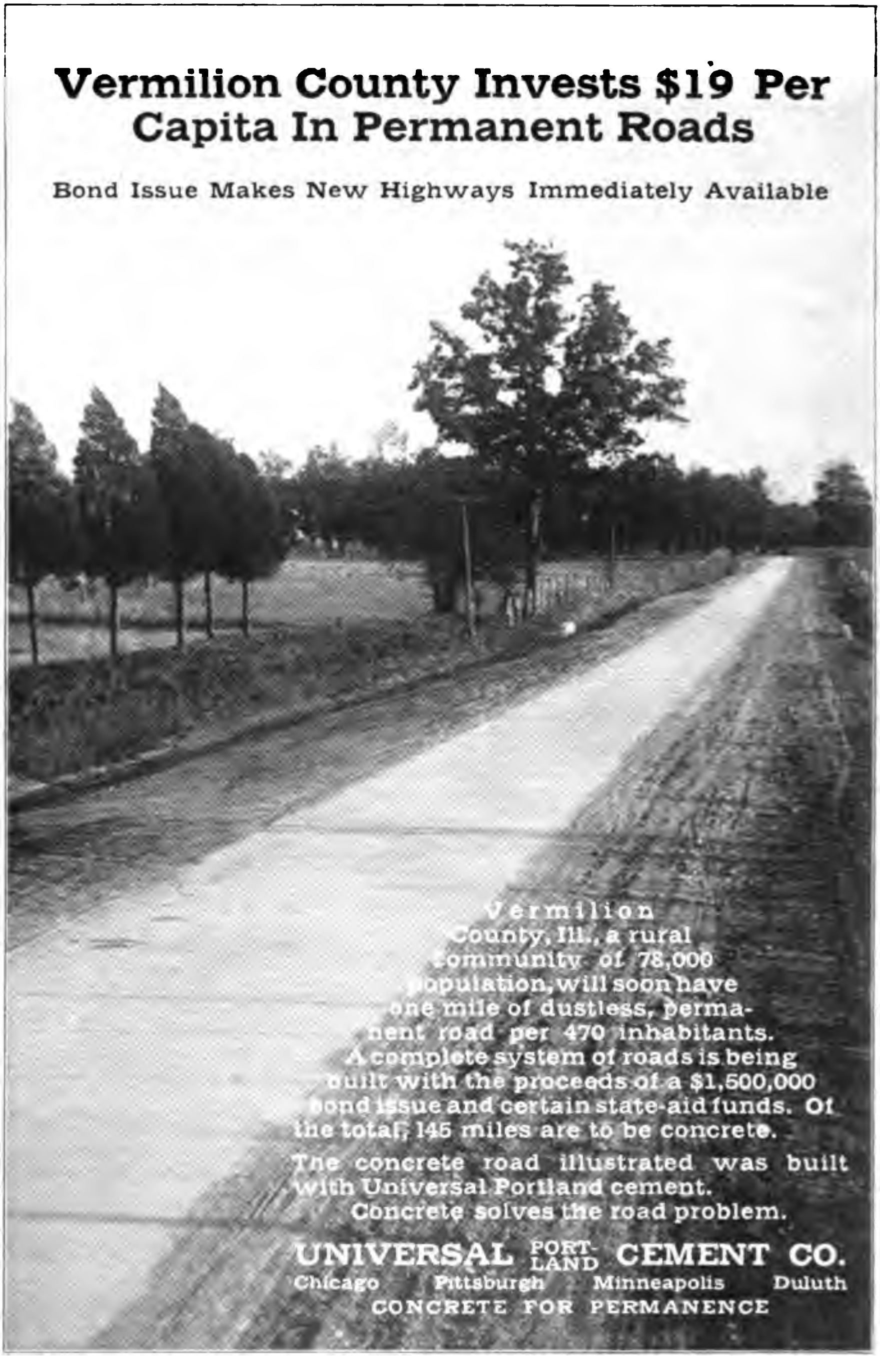

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Bond Issue Makes New Highways Immediately Available

Vermilion County, Ill., a rural community of 78,000 population, will soon have one mile of dustless, permanent road per 470 inhabitants. A complete system of roads is being built with the proceeds of a $1,500,000 bond issue and certain state-aid funds. Of the total, 145 miles are to be concrete.

The concrete road illustrated was built with Universal Portland cement.

Concrete solves the road problem.

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CONCRETE FOR PERMANENCE

Quantities of Cement, Sand and Stone in One Mile of Two-Course Concrete Road of Different Widths and Thicknesses

(Furnished by the Portland Cement Association)

WIDTH	BASE		VOLUME CONCRETE	BASE MIX; 1: 2½: 4			BASE MIX; 1: 2: 4			TOP		VOLUME CONCRETE	TOP MIX; 1½: 2½			TOP MIX; 1: 1: 1½		
	Thickness									Thickness								
	Side	Center		Cement	Sand	Stone	Cement	Sand	Stone	Side	Center		Cement	Sand	Stone	Cement	Sand	Stone
ft.	*ins.*	*ins.*	*cu. yds.*	*bbls.*	*cu. yds.*	*cu. yds.*	*bbls.*	*cu. yds.*	*cu. yds.*	*ins.*	*ins.*	*cu. yds.*	*bbls.*	*cu. yds.*	*cu. yds.*	*bbls.*	*cu. yds.*	*cu. yds.*
30	5	5	2445	3399	1247	2005	3692	1100	2176	2	2	977	2043	454	756	2902	429	644
10	4	5¼	787	1094	401	645	1188	354	700	2	2	326	682	152	253	968	143	215
10	5	6¼	951	1322	485	780	1436	428	846	2	2	326	682	152	253	968	143	215
12	4	5½	977	1358	498	801	1475	440	870	2	2	391	819	182	303	1161	172	258
12	5	6½	1173	1630	598	962	1771	528	1044	2	2	391	819	182	303	1161	172	258
14	4	5¾	1177	1636	600	965	1777	530	1048	2	2	456	955	212	354	1355	200	303
14	5	6¾	1407	1956	718	1154	2125	633	1254	2	2	456	955	212	354	1355	200	303
14	4	6	1216	1690	620	997	1836	547	1082	2	2	456	955	212	354	1355	200	303
14	5	7	1445	2009	737	1185	2182	650	1286	2	2	456	955	212	354	1355	200	303
16	4	6	1392	1935	710	1141	2102	626	1239	2	2	523	1091	243	404	1546	228	346
16	5	7	1651	2295	842	1354	2493	743	1469	2	2	523	1091	243	404	1546	228	346
18	4	6¼	1612	2241	822	1322	2434	725	1435	2	2	586	1226	272	454	1739	257	390
18	5	7¼	1906	2649	972	1563	2878	858	1696	2	2	586	1226	272	454	1739	257	390
20	4	6½	1846	2566	941	1514	2787	831	1643	2	2	651	1362	302	504	1935	286	429
20	5	7½	2174	3022	1109	1783	3283	978	1935	2	2	651	1362	302	504	1935	286	429
20	4	4	1304	1813	665	1069	1969	587	1161	2	2	651	1362	302	504	1935	286	429
20	5	5	1630	2266	831	1337	2461	734	1451	2	2	651	1362	302	504	1935	286	429
22	4	4	1434	1993	731	1176	2165	645	1276	2	2	716	1498	333	555	2128	315	472
22	5	5	1793	2492	914	1470	2707	807	1596	2	2	716	1498	333	555	2128	315	472
24	4	4	1563	2173	797	1282	2360	703	1391	2	2	781	1634	363	605	2322	343	515
24	5	5	1955	2717	997	1603	2952	880	1740	2	2	781	1634	363	605	2322	343	515
30	4	4	1955	2717	997	1603	2952	880	1740	2	2	977	2043	454	756	2902	429	644

Mixing

The principles that should govern mixing were stated as follows by the 1916 conference:

> The ingredients should be mixed in a batch mixer. The mixing should be continued for at least one minute after all the materials are in the mixer and before any of the concrete is discharged. The speed of the mixer should not exceed 16 revolutions per minute; however, the time and not the number of revolutions should be the gage of proper mixing.
>
> The practice is to mix concrete entirely too wet. The consistency should be such as not to require tamping, but not so wet as to cause the separation of the mortar from the aggregate in handling and placing. The strength and wearing qualities of the concrete are vitally lessened by an excess of water in mixing.

The reason for fixing one minute as the minimum time for mixing is that tests have shown that water is not worked through the mass as it should be in less than a minute. A smaller quantity of water can be used with long-time mixing than with short-time mixing and the same degree of fluidity obtained. On account of the desirability of keeping the amount of water as close as possible to 1 gallon per cubic yard of concrete, at least one minute mixing time is desirable. If a large quantity of water is used and the mixing time is less than a minute, the product may appear uniform to the eye when it actually is not well mixed.

The reason for restricting the speed of the mixer to 16 revolutions per minute is that at a higher speed some of the material sticks to the drum and there is considerable splashing as the concrete is discharged. At least 10 revolutions are necessary to mix the aggregate.

Placing

The principles governing placing were stated as follows by the 1916 conference:

> If the subgrade has been disturbed by teaming or other causes, it should be brought to its former surface, and thoroughly moistened with water. The concrete should be deposited rapidly to the required depth and width. The section should be completed to a transverse joint, with the use of intermediate forms or bulkheads, or a transverse joint may be placed at the point of stopping the work. In case the mixer breaks down the concrete should be mixed by hand to complete the section. Where reinforcement is used it should be embedded in the concrete before the concrete has begun to harden; the concrete above the reinforcement should be placed within 20 minutes after the placing of the concrete below.
>
> In two-course pavements the top should be placed within twenty minutes after the placing of the bottom.

The standard specifications allow forty-five minutes as the maximum time between the laying of the bottom course and the placing of the top course.

Practically all concrete roads are built with special paving mixers which discharge the concrete on the road where it is to be used by means of chutes or buckets hauled along a boom that can be swung from one side of the road to the other. The pitch of the chute should be steep enough to deliver concrete of a proper consistency readily. In the attempt to cover considerable area, contractors sometimes set the chute at a flat angle and use too much water, in order to make the concrete flow readily. Tests have shown that the least angle of the chute should be 20 degrees. If the chute is new or rusted, concrete with a proper amount of water will flow rather slowly down a 20 degree slope until the metal surface has been smoothed by the wet mass. For this reason the chute may need a steeper slope at the outset than later.

Forms

The 1916 conference adopted the following statement of the principles that should govern the use of forms to retain the concrete at the sides of the roadway:

> Metal forms of sufficient strength to withstand the necessary hard usage are preferred. When wooden forms are used they should be of at least 2-inch stock and capped with a 2-inch angle iron, so constructed that adjacent sections can be lapped. Forms should have a width not less than the thickness of the pavement at the sides. Particular care should be exercised to see that the top edges of forms are clean so as to avoid unevenness in the finished pavement. If forms are warped or stakes not properly placed, a poor alignment of the edge of the concrete slab will result.

They must be set firmly and the topes must be true to grade, because they support the templets, bridges and other appliances used in finishing the surface. The steel angles on wood forms are necessary to enable the finishing work to proceed in a satisfactory manner. By having the angles project 3 or 4 inches beyond the end of the wood at one end and set back the same distance at the other, the alignment of the forms will be facilitated. Painting wood forms will prevent warping and add to their life. Where a power-driven striking and finishing machine is used, specially heavy forms securely held in place are needed.

Joints

While transverse joints are omitted on some work, they are generally required because of the prevailing opinion that they reduce the cracking of the concrete. They are constructed by placing across the road a strip of prepared filler made for the purpose. This filler is usually held in place by a steel templet until the concrete is deposited against it. The templet is then removed and the concrete settles against the filler. The joints are of two types, with and without metal protection plates. The following statements regarding them were adopted at the 1916 conference:

> Transverse joints should be placed across the pavement perpendicular to the center line about 50 feet apart. There seems to be a tendency to lengthen the distance between joints. Joints should extend entirely through the pavement, as well as through the curb if integral curbs are used. Joints should be constructed perpendicularly to the surface of the pavement to avoid the possibility of one slab rising above the other.
>
> The tendency of present practice is toward the omission of metal protection plates for joints. It is possible that the value of metal protection plates is dependent somewhat on the character of the aggregate used, and it is considered that they are more essential in street pavements than in country highways.

The standard specifications call for ¼-inch transverse joints at intervals of not more than 36 feet. The filler must project at least ⅛-inch above the concrete during construction, and after the completion of the pavement it is trimmed off ¼-inch above the surface. The traffic flattens out the projecting material and hardens the top of the joints. Experience shows that it is very desirable to have the joints form a plane surface perpendicular to the surface of the road.

Measurements of the expansion and contraction of concrete roadway slabs have been made by R. J. Wig, C. S. Laubly and W. A. McIntyre, from which they drew the following conclusions: Contraction and expansion are caused by both temperature changes and changes in moisture conditions, and under climatic conditions similar to those at Washington, D. C., the effects from these two factors in concrete road surfaces are approximately of the same magnitude. In concrete roads, expansion and contraction are sufficient to cause frequent transverse cracks unless joints are provided. The actual movement in any particular case depends upon the character of the concrete and of the subgrade. A sloppy concrete shows greater movement than a concrete mixed only moderately wet.

Organization of the Work

In order for the work to proceed economically, it is necessary for the mixer to be kept running most of the time. This can only be accomplished if repair parts are kept on hand and materials are supplied as needed. If the materials are delivered by rail it often pays to keep men at the sand and stone plants to see that the railroads furnish cars as needed and the shipments are made on time. If the contractor operates his quarry he must see that precautions are taken to reduce delays due to breakdowns or other causes to a minimum. The delivery of materials along the road calls for careful planning of both plant and organization. In any case, provision should be made against delays due to insufficient materials by storing supplies of cement, sand and stone on the work. The cement can be stored in a shed at the railroad siding or in tents with raised wood floors along the road. The sand can also be stored along the road. The stone is best stored at the railroad siding, because it is costly to rehandle and by doing the work at one place mechanical appliances can be used which will reduce the expense materially. The organization should be arranged to avoid all unnecessary handling of materials, not only because this involves a labor charge but also because transportation equipment is doing no useful work while being loaded or unloaded. Tractors with trailers, motor trucks and industrial railways are generally used for hauling, and by having competent repairmen to keep them in order and running them with two shifts so as to use them about eighteen hours a day, very low unit costs are often obtained in comparison with the expense of hauling by horses or mules.

The water supply must be planned to wet the subgrade, supply the mixer and keep the concrete wet for a number of days after it is laid. While it has been delivered along the road in tanks, it is usually pumped through a pipe, generally 2 inches in diameter. As the water which must be used sometimes contains sand which will score the cylinders or plungers of a high pressure pump so as to put it out of service, it is often lifted by a centrifugal pump in such cases into a storage tank where the sand has an opportunity to settle before the water is drawn by the high-pressure pump. If the tank has two chambers separated by a partition running nearly up to the water level, the separation of. the sand will be improved, for the stream water can be delivered into one chamber where most of the sedimentation will occur and be drawn from the other. There should be a relief valve in the pipe line near the pressure pump so as to prevent breaking the pipe if all the gates on it are closed. If no valve is used the pump should be belt driven, so that in case the pressure rises the belt will slip. The friction head in a 2-inch pipe when discharging 50 gallons per minute is about 85 feet per 1000 feet of its length, and when discharging 60 gallons per minute the friction head is about 115 feet. Consequently the pump must have power to overcome a considerable pressure due to friction as well as that due to the highest elevation to which the water must be raised.

The size of the paving gang will depend upon the size of the mixer, which should depend in turn upon the rate at which materials can be delivered to it. There are two[1] sizes of mixers, one in which two sacks of cement are used in each batch of concrete and the other taking a three-sack batch. The smaller machine requires about two men handling cement, two shovelers and two wheelers for sand, three shovelers and three wheelers for stone, a helper at the mixer and a man to bundle the cement sacks. The larger machine requires about two men to handle cement, three shovelers and three helpers for sand, four shovelers and four wheelers for stone, a helper at the mixer and a man to bundle sacks. In addition the crew requires a foreman, a mixer operator, a fireman, two men setting forms, a pump tender, three or four men spreading and floating the concrete, two finishers, and one or two attending to the curing of the concrete. To keep such a gang working efficiently in the comparatively small area occupied by a concreting job it is necessary to have the materials deposited so they can be handled expeditiously and without confusion.

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[1] During 1916, four-sack mixers were used on several roads, so it is probable that there will be three sizes of mixers in regular use soon.

Finishing

The principles which should govern the finishing of concrete were stated as follows by the conference:

> **The surface of the concrete should be struck off by means of a templet moved with a combined longitudinal and transverse motion. The excess material accumulated in front of the templet should be uniformly distributed over the surface of the pavement except near the transverse joint, where the excess material should be removed.**
>
> **The concrete adjoining the transverse joint should be dense and any depressions in the surface should be filled with concrete of the same composition as the body of the work. After being brought to the established grade with a templet, the concrete should be finished, from a suitable bridge, with a wood float to true surface. A metal float should not be used.[1]**
>
> **Brooming of the surface is not necessary and grooves are objectionable even on grades.**

For country roads the templet or strikeboard is often made of two 2 by 10-inch planks 1 foot longer than the road is wide. The lower edge is cut to the desired crown of the road and shod with a strip of ½ by 4-inch steel fastened with countersunk screws. It has a handle on each side at each end, so it can be moved along easily with a kind of sawing motion. This motion fills all depressions with concrete and has no tendency to drag out the large stone. A slight excess o :concrete is always kept ahead of the strikeboard, and a workman often walks in front of the board to spread the concrete and take care of any excess that may accumulate in front of it. It is usually necessary to run the strikeboard over the surface three times; with very angular stone it may be necessary to go over it four times.

Finishing is now regarded as very important. At Sioux City, Iowa, where the concrete streets are unusually free from cracks, the success with this type of roads is attributed to the special care spent in the finishing. A wood float is preferred to a steel trowel for finishing because it is believed to make a more dense surface which is not slippery. The bridge from which the men work is a 2 x 12-inch plank, trussed to prevent deflection and supported by the side forms. No finishing should be done while there is free water on the surface. For finishing at unprotected joints a float split lengthwise, so as to fit over the joint filler, is used.

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[1] **Owing to the rapid development of belt finishing it is probable that finishing by wood floats will not be considered essential by many engineers after this year.**

Power finishing machines are now used to some extent as a substitute for hand finishing. They operate by rapidly increasing and decreasing the weight on the area of concrete on which they rest. These vibrations of load joggle the concrete, increasing its density and leaving a satisfactory finish when the concrete has a suitable consistency and the work is conducted carefully.

During 1915 and 1916, an increasing use has been made of belt finishing. The work is done with canvas belts from 12 to 24 inches wide. In Wayne County, Michigan, where the method has been used for the longest time, a 12-inch belt about 1 foot longer than the width of the road, is preferred. It has a handle at each end and is pulled gently back and forth across the surface after the latter has been shaped by the strikeboard. After the surface is finished in this way, it is gone over a second time with another belt, and sometimes a third time with a third belt. The belts are washed at the close of each day.

When belts are used for finishing it is desirable to shape the concrete with a strikeboard having a face about 8 inches wide and long handles like those of a plow at each end. With such a strikeboard the men can tamp as well as shape the concrete, and thus leave the surface in better condition for the belt than is the case with a thin strikeboard.

Curing

The protection and curing of the concrete must be carried on carefully because the best concrete may be seriously damaged by too rapid drying out of the surface in hot or windy weather, by exposure to low temperature or by being opened to traffic too soon. The principles which should govern the work were stated as follows by the 1916 conference:

> Even the best concrete may be seriously damaged by too rapid drying out, early exposure to low temperature, or by being opened to traffic at too early a period. Hot sun and drying winds are most liable to dry out the concrete too rapidly, thus causing shrinkage cracks or causing a surface which will not wear well under traffic. The use of a canvas covering will be found effective in overcoming this condition.
>
> Sprinkling should also be employed as soon as the concrete is hard enough to prevent the surface being pitted. An earth covering or protection by ponding should be employed after the first day. Under most favorable conditions such protection should be given the pavement for at least two weeks. Water should be added during this period to keep the concrete wet.
>
> In cool weather it is often advisable to omit the earth covering, thus allowing the concrete to harden more rapidly. Sprinkling should not be omitted during the day in case the surface shows a tendency to dry out. When there is danger of frost, sprinkling should be omitted and a covering of canvas or straw and canvas used.

Placing concrete in roads and pavements in temperatures at or near freezing is not advisable, and if in special cases, such work is unavoidable, the water and aggregate should be heated and precautions taken to protect the concrete from freezing for at least ten days.

Chemicals to lower the freezing temperature of the mixture should not be used. Concrete should not be deposited on a frozen subgrade.

The canvas provided for protection during hot and windy weather, should be sufficient to cover at least half the surface laid during a day. Strips 2 yards wide are used and they are about a yard longer than the width of the pavement so thateach end can be weighted. They are supported on frames so as not to touch the concrete, and are kept in place until the concrete has hardened.

The curing of concrete by ponding is not only more economical in many cases than the use of wet earth but it has a greater advantage in permitting the inspector to determine at a glance if the curing is proceeding properly. It is difficult to make certain that 'an earth covering is kept properly wet, but there can be no question whether water is standing on the concrete. Banks of earth are constructed along each edge of the pavement and transverse banks at each expansion joint and more frequently where the grades make them necessary. The water is kept at least 2 inches deep over the center of the road.

If there is danger of a heavy storm which will pit the surface of fresh concrete it must be protected by canvas. Contractors are advised to request the nearest forecasting station of the United States Weather Bureau to send its daily bulletin of the probable weather conditions during the next thirty-six hours.

The standard specifications require both water and aggregates to be heated if the temperature drops to 35 degrees or is likely to do so within twenty-four hours, and the concrete laid under these conditions must be specially protected from freezing for at least ten days. A canvas cover will be sufficient to protect the concrete against frost during the first night and after that about 3 inches of straw or marsh hay held down securely will probably serve. If a sharp lowering of the temperature is anticipated the straw should be covered with canvas. It is cheaper to take all necessary precautions than to tear out and replace damaged concrete. Even a light freezing of the top will make the surface scale.

Maintenance

The following explanation of methods of maintenance was prepared by A. H. Hinkle, L. C. Herrick, John W. Mueller and Maurice Hoeffken for the 1916 conference:

Joints and cracks can be successfully treated by thoroughly cleaning them and filling when dry, and preferably during warm weather, with hot tar, then covering with dry sand or screenings. The tar should be permitted to lap over the spalled edges of the crack, but not to exceed 1 inch. The most desirable covering is clean, coarse sand or clean screenings of stone, slag or gravel, that will pass a ½-inch circular opening, and be retained on a $\frac{1}{16}$-inch mesh screen. The tar should be poured when hot enough to run readily into the crevices of the pavement (about 200° to 250° F.). It is believed that no large excess of the tar should be used as the frequent use of such an excess might eventually build up an elevation on the surface which would be objectionable to traffic. The covering of screenings or sand should be put on immediately after pouring the tar so that while in the liquid state it will unite with the screenings or sand in sufficient degree to prevent the tar from sticking to wheels of vehicles or melting during hot periods and running from the cracks.

The use of a mastic consisting of a mixture of hot tar and sand, in place of pure tar, for filling the cracks and joints, gives promise of excellent results; but perhaps it is too soon to give definite specifications for this mixture. The filling of the larger and more open cracks or joints with the mastic, and the use of the pure tar for filling the minor openings in the pavement and such as are made necessary by settlement after the joints have been originally filled with the mastic, may be found to be most satisfactory.

A pouring can with a round or vertical spout is very satisfactory for pouring tar in filling cracks and joints. Inasmuch as it is desired that the tar shall lap over the edges of the crack or joint, the use of a conical pouring can would be of doubtful economy.

Small holes and shallow depressions can be successfully treated as follows: Clean surface thoroughly. Where the surface is disintegrated it should first be thoroughly swept with a steel broom in order to remove all loose spalls or foreign matter; afterward, the dust must be removed by sweeping with a rattan or house broom. The hot tar is then applied to the dry concrete and rubbed well with a squeegee or stiff broom to secure a good bond to the surface of the concrete. The tar is then covered with coarse sand or screenings (½ to $\frac{1}{16}$ inch) of stone, slag or gravel. The amount of tar used will vary from ½ to 1 gallon per square yard, depending upon the depth of the depression to be filled. When more than ½ gallon per square yard is used, it should be applied in two coats and the excess screenings swept off before the second coat is applied. The more tar that is applied to the surface, the more desirable it is to have the coarser material for a covering. In filling small holes the application of the tar in two layers would, of course be unnecessary.

To repair larger holes and deeper depressions than those discussed above: Thoroughly clean and paint the surface with tar. Fill the hole or depression with broken stone, preferably of such size that they will not exceed in diameter one-half the depth of the depression to be filled nor exceed in size stone suitable for an ordinary tar macadam. The stone should be levelled off and compacted as well as may be by tamping or rolling so as to conform to the true surface of the road. The voids are then filled with the hot tar and screenings applied to the surface, which is again compacted and treated as in building a tar macadam.

The use of a cold mix consisting of clean, hard stone chips coated with a coal tar cutback, for filling such holes and depressions, as described under the above paragraph, has been followed to some extent with very promising results. The stone chips are first thoroughly coated with the cold tar preparation by turning with shovels after the tar has been sprayed upon them, as in mixing ordinary cement concrete. The mixture is then permitted to stand a few days until the lighter oils vaporize from the tar, which leaves the stone coated with the heavy tar. The coated chips are then well tamped into the hole or depression to be filled, the shallower depressions being first painted with the pure tar. Coarse sand or fine screenings are then spread over the surface. If the voids appear quite open after the coated chips have been thoroughly tamped, a light application of the tar is made to seal up the voids before the surface screenings are applied.

Where the pavement is disintegrated badly or broken clear through so as to require rebuilding, it should be cut away with vertical edges. After the subgrade is levelled and compacted and the edges and subgrade thoroughly dampened (but the foundation not made muddy), the part cut away is replaced with new concrete conforming in quality as nearly as possible to the concrete of the surrounding pavement. It is well to coat the edges of the old concrete with cement grout. Care should be taken that the surface of the new concrete conforms to the surface of the adjacent concrete. The new concrete should be kept well dampened for about seven days, and protected from traffic (ten days in warm weather and much longer in cold weather) until thoroughly hardened. If the replacement is over an excavation the concrete should be properly reinforced.

STANDARD SPECIFICATIONS FOR PORTLAND CEMENT[1]

1. Portland cement is the product obtained by finely pulverizing clinker produced by calcining to incipient fusion, an intimate and properly proportioned mixture of argillaceous and calcareous materials, with no additions subsequent to calcination excepting water and calcined or uncalcined gypsum.

2. *Chemical Properties.*—The following limits shall not be exceeded:

Loss on ignition, per cent	4.00
Insoluble residue, per cent	0.85
Sulfuric anhydride (SO_3), per cent	2.00
Magnesia (MgO), per cent	5.00

3. *Physical Tests.*—The specific gravity of cement shall be not less than 3.10 (3.07 for white Portland cement). Should the test of cement as received fall below this requirement a second test may be made upon an ignited sample. The specific gravity test will not be made unless specifically ordered.

4. The residue on a standard No. 200 sieve shall not exceed 22 per cent by weight.

5. A pat of neat cement shall remain firm and hard, and show no signs of distortion, cracking, checking, or disintegration in the steam test for soundness.

6. The cement shall not develop initial set in less than forty-five minutes when the Vicat needle is used or sixty minutes when the Gillmore needle is used. Final set shall be attained within ten hours.

7. The average tensile strength in pounds per square inch of not less than three standard mortar briquettes composed of one part cement and three parts standard sand, by weight, shall be equal to or higher than the following:

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[1] Adopted by the American Society for Testing Materials in 1904 and revised in 1908, 1909 and 1916. These specifications are the result of several years' work of a special committee representing a United States Government Departmental Committee, the Board of Direction of the American Society of Civil Engineers and Committee C-1 on Cement of the American Society for Testing Materials, in cooperation with Committee C-1. The specifications as here printed are but the first part of the Society's "Standard Specifications and Tests for Portland Cement," as officially published.

AGE AT TEST	STORAGE OF BRIQUETTES	TENSILE STRENGTH
days		*lb. per sq.in.*
7	1 day in moist air, 6 days in water..................	200
28	1 day in moist air, 27 days in water.................	300

8. The average tensile strength of standard mortar at twenty-eight days shall be higher than the strength at seven days.

9. *Packages, Marking and Storage.*—The cement shall be delivered in suitable bags or barrels with the brand and name of the manufacturer plainly marked thereon, unless shipped in bulk. A bag shall contain 94 pounds net. A barrel shall contain 376 pounds net.

10. The cement shall be stored in such a manner as to permit easy access for proper inspection and identification of each shipment, and in a suitable weather-tight building which will protect the cement from dampness.

11. *Inspection.*—Every facility shall be provided the purchaser for careful sampling and inspection at either the mill or at the site of the work, as may be specified by the purchaser. At least ten days from the time of sampling shall be allowed for the completion of the 7-day test, and at least 31 days shall be allowed for the completion of the 28-day test. The cement shall be tested in accordance with the methods hereinafter prescribed. The 28-day test shall be waived only when specifically ordered.

12. *Rejection.*—The cement may be rejected if it fails to meet any of the requirements of these specifications.

13. Cement shall not be rejected on account of failure to meet the fineness requirement if upon retest after drying at 100°C. for one hour it meets this requirement.

14. Cement failing to meet the test for soundness in steam may be accepted if it passes a retest using a new sample at any time within 28 days thereafter.

15. Packages varying more than 5 per cent from the specified weight may be rejected; and if the average weight of packages in any shipment, as shown by weighing 50 packages taken at random, is less than that specified, the entire shipment may be rejected.

PETROLEUM AND RESIDUUMS[1]

A large part of the materials used as dust preventives and binders to hold together the mineral constituents of roads are obtained from petroleum. Petroleum is a term which covers mineral oils of a great variety of characteristics, all alike in being composed of a great variety of complex chemical compounds called hydrocarbons, of which there is a very large number. The investigation of the properties of these hydrocarbons and their derivatives requires a knowledge of organic chemistry which few roadbuilders possess, and because some of them have attempted to tread the veritable mazes of this extremely complicated domain of chemistry, no little confusion has arisen. The main facts regarding petroleum and the other hydrocarbons used in roadbuilding are definitely known, but the details of any group of these compounds are best left for the chemical specialist, who is making steady progress in his researches concerning them.

Paraffin and Asphaltic Oils

The roadbuilder's interest in petroleum is largely in its base, a term used to designate a part of oil left after distilling off the more volatile portions. The base is sometimes made up of compounds of the paraffin group or series, as chemists term such allied compounds. Marsh gas is a member of the paraffin series, and its least complex representative. A few other members are gases but most of them are liquids or solids, and their number is legion. The base of other petroleums is made up of compounds called polycyclic polymethylenes by the chemist, and as these compounds occur in native asphalts such a base is called asphaltic. The base of other petroleums is made up of both paraffin and asphaltic compounds and such petroleums are called semi-asphaltic.

The gaseous hydrocarbons are of no interest to the roadbuilder. The liquid and solid hydrocarbons are what determine the value of petroleum for his purposes. The liquid and solid paraffins are greasy materials without binding properties, while the asphaltic materials are sticky. Consequently the roadbuilding value of petroleum depends upon the asphaltic compounds in its base.

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[1] Revised by Prévost Hubbard, chief of road materials tests and research, United States Office of Public Roads.

Paraffin oils have been used successfully as dust preventives when sprinkled in small quantities on a clean road, but if used in large quantities they form a greasy, dirty surface and seem to lubricate the pieces of stone in the road, which becomes rutted rapidly.

Petroleum is obtained from many districts, which are called fields in the industry. The leading fields which supply or have supplied materials for roadbuilding in the United States are discribed substantially as follows by John D. Northrop in *Mineral Resources of the United States, 1916:*

1. The Appalachian field embraces all oil pools east of central Ohio and north of central Alabama, including those of New York, Pennsylvania, West Virginia, southeastern Ohio, Kentucky, Tennessee, and northern Alabama. The oils of the Appalachian field are in the main of paraffin base, free from asphalt and practically free from sulphur, and they yield by ordinary refining methods high percentages of gasoline and illuminating oils—the products in greatest demand.

2. The Lima-Indiana field embraces all areas of oil production in the northwestern part of Ohio and in Indiana. The petroleum of the Lima-Indiana field contains some asphalt, though consisting chiefly of paraffin hydrocarbons with sulphur compounds.

3. The Illinois field lies in the southeastern, south-central and western parts of the State, comprising about 16 counties. Illinois oils contain varying proportions of both asphalt and paraffin and differ considerably as to specific gravity and distillation products. Sulphur is generally present.

For commercial purposes it is customary to group under the title "Mid-Continent field" the areas of oil production in Kansas, Oklahoma, northern and central Texas, and northern Louisiana. Mid-continent oils vary in composition within wide limits, ranging from asphaltic oils poor in gasoline and illuminants, to oils in which the asphalt content is negligible and the paraffin content relatively high and which yield correspondingly high percentages of the lighter products on distillation. Sulphur is present in varying quantities in the lower grade oils.

5. The term "Gulf field" includes that portion of the gulf coastal plain of Texas and Louisiana in which petroleum is found in domes, associated with rock salt and gypsum. Oils from the Gulf field are characterized by relatively high percentages of asphalt and low percentages of the lighter gravity distillation products. Considerable sulphur is present, much of which, however, is in the form of sulphureted hydrogen and is easily removed by steam before refining or utilizing the oil as fuel.

6. The California field is mainly located in Kern, Fresno, Orange, Santa Barbara and Los Angeles Counties. The Cali-

fornia oils are generally characterized by much asphalt and little or no paraffin and by small proportions of sulphur. The chief products are fuel oils, lamp oils, lubricants, and oil asphalt.

Oils from Wyoming and Colorado are in the main of paraffin base, suitable for refining by ordinary methods. Heavy asphaltic oils are also obtained in certain of the Wyoming fields.

7. Mexican field. This extends along the Gulf of Mexico from the vicinity of Tampico to the vicinity of Tuxpan, and produces asphaltic and semi-asphaltic petroleum.

8. Trinidad field. A large amount of asphaltic petroleum is produced on the island of Trinidad.

Clifford Richardson gives the following explanation of the relation between this petroleum and Trinidad asphalt:

> Rising from the sands in which it occurs and coming in contact with the colloidal clay forming a portion of the mud existing below the crater or depression which holds the asphalt, it is emulsified with it and converted into the material which we recognize as Trinidad lake asphalt.

Refining Petroleum

Crude asphaltic petroleum has been used as a dust preventive and as a binder, but generally the petroleum is refined to obtain a number of valuable materials occurring in it. The crude oil is first allowed to settle in tanks in which the mineral matter

Petroleum Marketed in the United States in 1915 by Fields
(John D. Northrop, in *Mineral Resources of the United States*, 1915)

FIELD.	QUANTITY (BARRELS OF 42 GALLONS)	VALUE	AVERAGE PRICE PER BARREL
Appalachian	22,860,048	$35,468,973	$1.552
Lima-Indiana	4,269,591	4,114, 228	0.964
Illinois	19,041,695	18,655,850	0.980
Mid-continent	123,295,867	72,437,701	0.588
Gulf	20,577,103	9,802,901	0.476
California	86,591,535	36,558,439	0.422
Colorado and Wyoming	4,454,000	2,400,503	0.539
Other fields	14,265*	24,295*	1.703
	281,104,104	$179,462,890	$0.638

* Includes Alaska, Michigan, and Missouri.

NOTE: The Barber Asphalt Company reports that the importation of crude petroleum from Trinidad has been as follows: 1914, 140,438 barrels; 1915, 330,022 barrels; 1916, 372,000 barrels. The imports of crude petroleum from Mexico are reported by John D. Northrop as follows: 1914, 16,245,975; 1915, 17,478,472 barrels.

A preliminary estimate by J. D. Northrop of the 1916 production in the United States is 292,300,000 barrels.

Degrees Baumé, Specific Gravities, Weights in Pounds per Gallon and Volume in Gallons per Pound of Petroleum at 60°F.

(From "United States Standard Tables for Petroleum Oils," United States Bureau of Standards)

DEGREES BAUMÉ	SPECIFIC GRAVITY	POUNDS PER GALLON	GALLONS PER POUND	DEGREES BAUMÉ	SPECIFIC GRAVITY	POUNDS PER GALLON	GALLONS PER POUND
10.0	1.0000	8.328	0.1201	19.6	0.9358	7.793	0.1283
10.2	0.9986	8.317	0.1202	19.8	0.9346	7.783	0.1285
10.4	0.9972	8.305	0.1204	20.0	0.9333	7.772	0.1287
10.6	0.9957	8.293	0.1206	20.2	0.9321	7.762	0.1288
10.8	0.9943	8.281	0.1208	20.4	0.9309	7.752	0.1290
11.0	0.9929	8.269	0.1209	20.6	0.9296	7.742	0.1292
11.2	0.9915	8.258	0.1211	20.8	0.9284	7.731	0.1293
11.4	0.9901	8.246	0.1213	21.0	0.9272	7.721	0.1295
11.6	0.9887	8.234	0.1214	21.2	0.9259	7.711	0.1297
11.8	0.9873	8.223	0.1216	21.4	0.9247	7.701	0.1299
12.0	0.9859	8.211	0.1218	21.6	0.9235	7.690	0.1300
12.2	0.9845	8.199	0.1220	21.8	0.9223	7.680	0.1302
12.4	0.9831	8.188	0.1221	22.0	0.9211	7.670	0.1304
12.6	0.9818	8.176	0.1223	22.2	0.9198	7.660	0.1305
12.8	0.9804	8.165	0.1225	22.4	0.9186	7.650	0.1307
13.0	0.9790	8.153	0.1227	22.6	0.9174	7.640	0.1309
13.2	0.9777	8.142	0.1228	22.8	0.9162	7.630	0.1311
13.4	0.9763	8.131	0.1230	23.0	0.9150	7.620	0.1313
13.6	0.9749	8.119	0.1232	23.2	0.9138	7.610	0.1314
13.8	0.9736	8.108	0.1233	23.4	0.9126	7.600	0.1316
14.0	0.9722	8.096	0.1235	23.6	0.9115	7.590	0.1318
14.2	0.9709	8.086	0.1237	23.8	0.9103	7.580	0.1319
14.4	0.9695	8.074	0.1239	24.0	0.9091	7.570	0.1321
14.6	0.9682	8.063	0.1240	24.2	0.9079	7.561	0.1323
14.8	0.9669	8.052	0.1242	24.4	0.9067	7.551	0.1324
15.0	0.9655	8.041	0.1244	24.6	0.9056	7.541	0.1326
15.2	0.9642	8.030	0.1245	24.8	0.9044	7.531	0.1328
15.4	0.9629	8.019	0.1247	25.0	0.9032	7.522	0.1330
15.6	0.9615	8.007	0.1249	25.2	0.9021	7.512	0.1331
15.8	0.9602	7.997	0.1250	25.4	0.9009	7.502	0.1333
16.0	0.9589	7.986	0.1252	25.6	0.8997	7.493	0.1335
16.2	0.9576	7.975	0.1254	25.8	0.8986	7.483	0.1336
16.4	0.9563	7.964	0.1256	26.0	0.8974	7.473	0.1338
16.6	0.9550	7.953	0.1257	26.2	0.8963	7.464	0.1340
16.8	0.9537	7.942	0.1259	26.4	0.8951	7.454	0.1342
17.0	0.9524	7.931	0.1261	26.6	0.8940	7.445	0.1343
17.2	0.9511	7.921	0.1262	26.8	0.8929	7.435	0.1345
17.4	0.9498	7.910	0.1264	27.0	0.8917	7.425	0.1347
17.6	0.9485	7.899	0.1266	27.2	0.8906	7.416	0.1348
17.8	0.9472	7.888	0.1268	27.4	0.8895	7.407	0.1350
18.0	0.9459	7.877	0.1270	27.6	0.8883	7.397	0.1352
18.2	0.9447	7.867	0.1271	27.8	0.8872	7.388	0.1354
18.4	0.9434	7.856	0.1273	28.0	0.8861	7.378	0.1355
18.6	0.9421	7.846	0.1275	28.2	0.8850	7.369	0.1357
18.8	0.9409	7.835	0.1276	28.4	0.8838	7.360	0.1359
19.0	0.9396	7.825	0.1278	28.6	0.8827	7.351	0.1360
19.2	0.9383	7.814	0.1280	28.8	0.8816	7.341	0.1362
19.4	0.9371	7.804	0.1281	29.0	0.8805	7.332	0.1364

NOTE: Tables for oils of greater specific gravity than 1.000 and of the comparative volumes of oils at 60° and other temperatures are given on pages 376 and 378.

and water are separated from the oil. The latter is drawn off into cylindrical stills set horizontally in brickwork like boilers. There is a furnace below the still, and the latter contains steam coils and sometimes steam jets at the bottom of the stills. The heating by means of the furnace and the steam coils and jets should be conducted very carefully, if the final products are to be used for road work, and careless heating has resulted in very undesirable materials being sold for highway purposes. The vapors from the stills are removed to condensers and liquefied.

The distillate that is obtained until the temperature reaches about 300°F. and the specific gravity of the product is about 0.73 is refined to furnish gasoline and naphtha. While the temperature is increased from 300° to 575°F., the specific gravity of the distillate increases to about 0.82, and the oil produced during this stage is treated to supply kerosene. If it is desirable to produce as much kerosene as possible the furnace is heated and the sides of the still kept as cool as possible, so that some of the heavy vapor driven off in the bottom of the still will condense in the top and fall back into the much hotter material at the bottom, "cracking" these heavy vapors into lighter compounds. One result of such cracking is often the liberation of free carbon, which settles into the material in the bottom of the still. Asphaltic oils can be cracked at a lower temperature than paraffin oils.

If road oils for surface treatment are desired, the distilling process is stopped after the light distillates are driven off. The thick oil left in the still is called the residuum, and some people look upon it as a by-product and the name "residuum" as having a somewhat derogatory signification. As a matter of fact the residuum obtained in distilling some petroleums is by far the most important product obtained from them. Some Californian and Mexican oils contain such a large amount of asphaltic compounds and so little light oils that by stopping the refining process when the residuum has the consistency desired for some classes of paving materials, it is unnecessary to add any other bitumen to fit it for use.

In the patented Trumbull process, the oil is heated and then allowed to flow down the inner surface of a large vertical heated cylinder. The vapors are drawn from the top of the cylinder and the asphaltic residuum is collected at the bottom. The temperatures used and the rate at which the crude oil is fed to the top of the cylinder fix the consistency of the residuum.

One of the earliest attempts to improve the process of refining petroleum so as to yield the maximum quantity of products useful for paving was made by Dubbs. By adding sulphur to the residuum while it was at a high temperature he produced mate-

ANDERSON & GUSTAFSON
DISTILLATES, ROAD OILS, FLUX OILS
CHICAGO
TRANSPORTATION BUILDING
Tulsa, Okla. New York
Daniel Building Woolworth Building
Kansas City, Mo., Finance Building

ASSOCIATED OIL COMPANY
California Asphalt Products for Roads
SAN FRANCISCO, CALIFORNIA
Sharon Building

HYDROLENE
Asphalt Products for Road Building
are Unsurpassed
SUN COMPANY
Toledo, Ohio. Philadelphia, Pa. Chicago, Ill.

The Cushing Refining Company
The Producers Refining Company
The Ponca Refining Company
Petroleum Products for Road Work
COLCORD BUILDING, OKLAHOMA CITY
George A. Todd, Mgr.

The Midwest Refining Company
Producers and Refiners of
WYOMING AND MONTANA OILS
DENVER, COLORADO

General Petroleum Company
Asphaltic Road Materials
SAN FRANCISCO, CALIFORNIA

SINCLAIR
REFINING COMPANY
ROAD OILS

New York, U. S. A.
120 Broadway

Cable Address
Sorcorp

Chicago, U. S. A.
Conway Building

PURE OIL COMPANY
Producers of Petroleum Products
PHILADELPHIA, PENNSYLVANIA
Lafayette Building

Mexican Petroleum Corporation
Producers of Asphaltic
Road Materials
52 BROADWAY, NEW YORK

UNION OIL COMPANY OF CALIFORNIA
Asphalt Road Oils
Los Angeles San Francisco
California

SAPULPA REFINING COMPANY
Straight Run Gasoline
Highest Quality
SAPULPA, OKLAHOMA

TIDE WATER OIL COMPANY
DUST-LAYING OILS
11 BROADWAY, NEW YORK

Standard Oil Company of California
California Asphalt Products
SAN FRANCISCO, CALIFORNIA

rials which have been widely used as fluxes. About the same time Byerly found that by blowing air through the heated residuum asphaltic products were obtained, the oxygen performing the same function as the sulphur used in the Dubbs process. Some of these blown-oil products have been used as fluxes and others have been used for a great variety of purposes. Some asphaltic oils furnish a residuum which does not require blowing to obtain road material but this treatment is generally employed with semi-asphaltic oils when such a product is desired. Apparently the hydrocarbons of the paraffin series are little affected by the blowing process, which affects compounds of other series.

Meaning of Analyses.—The characteristics of the residuums from various oils are given in the accompanying table. The following notes explain the significance of the information in the table, and are abridged from Prévost Hubbard's *Dust Preventives and Road Binders.*

Specific Gravity.—The mark "25°/25°C." indicates that the determination was made at 25°C. (77°F.) and the result expressed in comparison with water at the same temperature. The test is mainly useful in identifying the material, but also gives a rough indication of the amount of heavy hydrocarbons which give body to the material. Material having a specific gravity exceeding 0.93 or 0.94 should be heated before use.

Flash Point.—This test is of value as differentiating between the heavy crude oils and cut-back[1] products, and the fluid residuums. It also shows the point to which a refined oil has been distilled and whether it is advisable to heat the material before application.

Loss at 160°C.—The loss in weight is an indication of the relative losses by volatilization of different road oils in actual service. It is an empirical test, like the rattler test for paving bricks. The residue should be sticky. If it is desirable for the material to maintain its consistency after application, it should show a low loss. If the material is applied by a method which requires more or less fluidity, a high loss is permissible, in order that the material may rapidly attain the desired consistency in the road, although a high loss is not necessary in the case of dust preventives. The loss is now usually determined at 163°C.

Loss at 205°C.—The purpose of this test is to show the effect of a high temperature as compared with 160° or 163°. It is not often made.

Bitumen Soluble in CS_2.—The solubility of the bitumen itself is independent of its character and consistency, so the amount and character of insoluble material is of most interest.

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[1] A cut-back product is one made by fluxing a dense asphalt with a light oil.

Properties of the Residuums from Different Petroleums
(Mainly from *Dust Preventives and Road Binders*, by Prévost Hubbard)

	PENNSYLVANIA OIL RESIDUUM	OHIO OIL RESIDUUM	ILLINOIS OIL RESIDUUM†	KANSAS OIL RESIDUUM	GULF OIL RESIDUUM	CALIFORNIA OIL RESIDUUM	SEMIASPHALTIC BLOWN OIL	MEXICAN OIL RESIDUUM
Specific gravity, 25°/25°C.	0.9202	0.9318	0.941	0.9328	0.9735	1.006	0.974	1.000
Flash point, degrees C.	186.0	224.0	187.0	196.0	214.0	191.0	260.0	196.0
Loss at 160°C., 7 hours, per cent	5.3	0.3	1.46‡	2.6¶	0.8	3.2	0.18‡	4.0
Character of residue	Soft	Soft	Soft	Soft	Soft	Soft	....	Fluid
Loss at 205°C., 7 hours, per cent	14.2	7.4*	....	5.7*	6.2*	17.3*	0.68	....
Character of residue	Soft	Soft	....	Soft	Soft	Soft	Dense	....
Bitumen soluble in CS_2, air temperature, per cent	99.8	99.4	99.8	....	99.6	99.7	99.92	100.00
Organic matter insoluble, per cent	0.2	0.6	....	....	0.4	0.3	....	0.0
Inorganic matter, per cent	....	....	....	....	....	....	....	0.0
Bitumen insoluble in 88°B. naphtha, air temperature, per cent	4.3	3.8	5.9§	3.6	4.8	7.7	22.05§	15.00
Soluble bitumen removed by H_2SO_4, per cent	21.9	17.0	....	14.4	20.9	54.9	25.16	....
Saturated hydrocarbons in total bitumen, per cent	74.8	83.0	....	....	79.4	41.9	74.84	....
Solid paraffin, per cent	11.0	11.4	....	7.8	1.7	0.0	5.1	0.0
Fixed carbon, per cent	3.0	3.7	4.0	4.1	3.5	6.0	....	9.0

* Loss at 200°C. † Viscous, slightly sticky. ‡ Loss at 163°, 5 hours.
§86°B. naphtha. ¶ 100°, 7 hours. ‖Sticky and somewhat harder than original material.

Inorganic Matter.—This indicates in some cases the nature of the dense bitumen.

Insoluble Organic Matter.—This affords an indication of whether oil has been distilled destructively.

Bitumen Insoluble in 88°B. Naphtha.—The hydrocarbons insoluble in paraffin naphtha are termed "asphaltenes" and those which are soluble "malthenes." The former tend to give body and consistency and the latter contribute adhesive properties to a road material. Blown oils contain very high amounts of insoluble hydrocarbons, sometimes as much as 25 to 30 per cent. The character of the bitumen dissolved in naphtha, after the solvent has evaporated, is instructive, for a sticky residue indicates better road building qualities in the original material than that which is greasy.

Soluble Bitumen Removed by H_2SO_4 and Saturated Hydrocarbons in Total Bitumen.—These tests are mainly of value as indicating the source of the material under examination. Clifford Richardson gives the following explanation of the significance of the tests in *The Modern Asphalt Pavement:*

> Hydrocarbons in general are divided into those which are saturated and those which are unsaturated, the former being stable and the latter reactive and very susceptible to change, combining with or being converted into other hydrocarbons by the action of sulphuric acid and other reagents. The saturated can be separated from the unsaturated hydrocarbons by strong sulphuric acid, and this will be found to be a very important means of differentiating the oils and the solid bitumens among themselves, by determining the relative proportions of these two classes of hydrocarbons which they contain.

Solid Paraffin.—This test confirms the information obtained from an inspection of the residue after the test of the loss at 160°C. The heavy liquid hydrocarbons of the paraffin series are probably more detrimental in road oils than are the solid paraffins.

Fixed Carbon.—Fixed carbon is the coke resulting from the ignition of the bitumen in the absence of oxygen.

Fluxes.

Fluxes are petroleum products which are mixed with harder bituminous materials to soften them to any desired consistency. Petroleum with a paraffin base furnished the first flux used in the asphalt paving industry.

Asphaltic or semi-asphaltic flux is the residuum left on distilling petroleum having an asphaltic or semi-asphaltic base to a point where the residuum is a dense liquid when cool but any further distillation will produce a solid residuum when cold. It is characterized by a relatively low amount of saturated hydrocarbons. While it resembles natural maltha in some respects, it differs in remaining soft after heating to 400°F., most malthas becoming hard pitches after such treatment.

ASPHALT AND NATIVE SOLID BITUMENS[1]

The following definition of "asphalt" has been adopted by the American Society for Testing Materials:

> Solid or semi-solid native bitumens, solid or semi-solid[2] bitumens obtained by refining petroleum, or solid or semi-solid bitumens which are combinations of the bitumens mentioned with petroleums or derivatives thereof, which melt upon the application of heat and which consist of a mixture of hydrocarbons and their derivatives of complex structure, largely cyclic and bridge compounds.

This definition is dependent upon the same society's definition of "bitumens," which is:

> Mixtures of native or pyrogenous hydrocarbons and their non-metallic derivatives, which may be gases, liquids, viscous liquids, or solids, and which are soluble in carbon disulphide.

These definitions were prepared after numerous conferences of road engineers and producers of materials, and while adopted by the society are not accepted by all specialists.

The following definitions are given by Clifford Richardson in *The Modern Asphalt Pavement:*

> Native bitumens consist of a mixture of native hydrocarbons and their derivatives, which may be gaseous, liquid, a viscous liquid or solid, but, if solid, melting more or less readily on the application of heat, and soluble in turpentine, chloroform, bisulphide of carbon, similar solvents, and in the malthas or heavy asphaltic oils. Natural gas, petroleum, maltha, asphalt, grahamite, gilsonite, ozocerite, etc., are bitumens. Coal, lignite, wurtzelite, albertite, so-called indurated asphalts, are not bitumens, because they are not soluble to any extent in the usual solvents for bitumen, nor do they melt at comparatively low temperatures nor dissolve in heavy asphaltic oils. These substances, however, on destructive distillation

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[1] Revised by Prévost Hubbard, chief of road materials tests and research, United States Office of Public Roads.

[2] Solid bituminous materials are those having a penetration at 25°C. (77°F.) under a load of 100 grams applied for five seconds, of not more than 10. The significance of "penetration" is explained on page 368.

Semi-solid bituminous materials are those having a penetration at 25°C. (77° F.) under a load of 100 grams applied for five seconds, of more than 10 and a penetration under a load of 50 grams applied for 1 second of not more than 350.

Liquid bituminous materials are those having a penetration at 25°C. (77° F).) under a load of 50 grams applied for one second or more than 350.

give rise to products which are similar to natural bitumens, and they have been on this account defined by T. Sterry Hunt as "pyro-bitumens," which differentiates them very plainly from the true bitumens."

Asphalt is a term used industrially to cover all the solid native bitumens used in the paving industry and specifically to include only such as melt on the application of heat, at about the temperature of boiling water, are equally soluble in carbon bisulphide and carbon tetrachloride and to a large extent in 88° naphtha, those hydrocarbons soluble in naphtha consisting to a very considerable degree of saturated hydrocarbons, yielding about 15 per cent of fixed carbon and containing a high percentage of sulphur. Under this definition it can be seen that grahamite is not an asphalt, since it is not largely soluble in naphtha and yields a very high percentage of fixed carbon on ignition. It is also less soluble in carbon tetrachloride than in carbon bisulphide. Gilsonite is not an asphalt, since the saturated hydrocarbons contained in the naphtha solution are very small in amount and quite different in character from those found in asphalt.

Roadbuilders use the term "natural asphalts" to designate the native solid or semi-solid asphalts, and "oil asphalts" to designate the corresponding materials prepared from petroleum or maltha. Some producers of oil asphalts object to the term on the ground that the material obtained by distilling away the lighter parts of asphaltic petroleum is as "natural" as that obtained by refining native asphalts. By "rock asphalt" is meant sandstone and limestone impregnated with asphalt or maltha. "Asphaltic sands" are mixtures of asphalt or maltha and sand, the latter in loose grains which fall apart when the bitumen is extracted; many of them are called rock asphalts because in their natural condition the maltha cements them into a rock-like mass.

The sources of the asphalts used in the United States are given in the accompanying table. The quantities of materials there stated were not all used for road and street purposes, as there are many other uses to which some of them are put.

Trinidad Asphalt.—Trinidad asphalt comes from the island of that name. The main source is on La Brea Point, about 28 miles from Port of Spain, the chief town. Here there is a circular pitch lake of nearly 115 acres extent, between which and the sea are other pitch deposits more or less mixed with sand. The former furnishes the "lake asphalt" and the latter the "land asphalt" of the paving industry.

The material in the lake is described by Clifford Richardson as an emulsion of water, gas, bitumen, fine sand and clay. It is in constant motion owing to the evolution of gas, and for this reason, whenever a hole is dug in the surface, whether deep or shallow, it rapidly fills up and the surface resumes its original level after a short time. Although soft it can be readily flaked out with picks in large conchoidal masses weighing 50 to 75 pounds. It is honey-combed with gas cavities and resembles a Swiss cheese in structure. It is of uniform composition, as follows: Water and gas volatilized at 100°C., 29 per cent; bitumen soluble in cold carbon disulphide, 39 per cent; bitumen absorbed by mineral matter, 0.3 per cent; mineral matter, 27.2 per cent; water of hydration in clay and silicates, 4.3 per cent.

American Production and Importation of Asphaltic Materials, 1915

(Compiled from report by John D. Northrop in *Mineral Resources of the United States*, 1915. Output stated in tons of 2000 pounds, except in case of imports, which are in tons of 2240 pounds)

	1915		1914	
	Tons	Value	Tons	Value
American bituminous rock....	44,329	$157,083	51,071	$162,622
Wurtzelite (elaterite), gilsonite	20,559	275,252	19,148	405,966
Grahamite....................	10,863	94,155	9,669	73,535
Total American natural bituminous material............	75,751	526,490	79,888	642,123
American road oils and fluxes.	417,859	2,392,576	171,447	....
American oil asphalts and pitches....................	246,644	2,323,007	189,408	....
Total American road oils, asphalts, etc.................	664,503	4,715,583	360,855†	3,016,969
Mexican road oils and fluxes*	174,854	1,325,201	111,058	....
Mexican oil asphalts and pitches*...................	213,464	2,405,235	202,729	....
Total Mexican road oils, asphalts, etc*................	388,318	3,730,436	313,787	4,131,153
Imports of asphalt				
Trinidad†..................	92,107	498,900	61,708	334,635
Bermudez..................	28,659	144,595	58,755	295,765
Cuba......................	391	9,243	458	11,407
Barbados..................	64	6,426	71	6,592
Mexico....................	56	755	140	2,048
Switzerland................	200	1,637	620	3,706
Italy......................	492	3,438	247	1,477
France....................	....	....	100	1,317
England...................	774	9,801	628	6,269
Germany..................	658	4,854	1,354	10,856

* Refined in the United States from imported Mexican petroleum.

† There are discrepancies in the figures in the report.

Trinidad land asphalt reached the places where it is found either by overflowing from the lake or by intrusion into the soil from the same subterranean source that supplies the lake asphalt.

Its character is much affected by the effect of the weathering to which it has been subjected. Clifford Richardson states that refined land asphalt of good quality differs from the lake supply by its higher specific gravity due to the larger amount of mineral matter it contains, by a higher softening or melting point, and a somewhat lower percentage of bitumen and, in consequence of these facts, a much greater hardness at all temperatures. Land asphalt requires much more paraffin flux than lake asphalt, and asphaltic oil fluxes offer certain advantages over paraffin fluxes for use with land asphalt.

Composition of Refined Trinidad and Bermudez Asphalts
(Clifford Richardson)

	TRINIDAD	BERMUDEZ
Specific gravity at 77°F. (25°C.)	1.40	1.08
Streak	Blue black	Black
Lustre	Dull	Bright
Structure	Homogeneous	Uniform
Fracture	Semi-conchoidal	Semi-conchoidal
Hardness	2	Soft
Melts	235°F. (113°C.)	183°F. (84°C.)
Penetration at 77°F. (25°C.)	4	20
Loss at 325°F. (163°C.), 7 hours	1.1%	3%
Character of residue	Smooth	Smooth
Loss at 400°F. (205°C.) 7 hours	4.0%	8.2%
Character of residue	Blistered	Wrinkled
Bitumen soluble in CS_2	56.5%	94.4%
Bitumen retained by mineral matter	0.3%	....
Mineral matter	38.5%	3.6%
Water of hydration	4.2%	....
Vegetable matter	....	2.0%
Bitumen soluble in 88° naphtha	35.6%	62.2%
Percentage of total bitumen which above is	63.1%	65.4%
Soluble bitumen removed by H_2SO_4	61.3%	62.4%
Saturated hydrocarbons in total bitumen	24.4%	24.4%
Pure bitumen soluble in CCl_4	100.0%	99.5%
Fixed carbon	10.8%	13.4%

Bermudez Asphalt.—Bermudez asphalt comes from a pitch lake in Venezuela about 30 miles from the coast in an air line. The lake is about 1½ miles long, 1 mile wide, of irregular shape and covers about 900 acres. It is covered with a crust from a few inches to 2 feet thick, having some grass and shrubs, with a few palms, and the pitch is visible on the surface in but few places. It is very wet, so that excavations fill with water and it is difficult to excavate the pitch, which has an average depth of 4 feet. The deposit is probably formed by the exudation of a large quantity of soft maltha. The asphalt from the lake varies greatly in the amount of water it contains, which fluctuates between 11 and 46 per cent. This water is not emulsified with the bitumen but is adventitious surface water. The material for industrial use is selected, and when refined has the composition given in the accompanying table, which also gives the composition of refined Trinidad asphalt.

Meaning of Analyses.—The significance of most of the terms used in this table are explained in the section on Petroleum. The new terms are the following:

Streak is the color of a rubbed or scratched surface.

Hardness is stated in terms of Mohr's scale, in which 1 is the hardness of talc, 2 that of rock salt, 3 that of calcite, 4 that of fluorite, etc. When a bitumen is softer than I on this scale its hardness is stated by its behavior in a penetration test, explained below.

Melting point is determined by an arbitrary test, because bituminous materials are made up of a mixture of hydrocarbons and their derivatives and can not have a true melting point, such as a definite compound possesses.

Penetration is determined by the distance that a needle of specified size loaded with a specified weight will penetrate into a sample of the material in a specified time. Usually a No. 2 needle loaded so that the total weight is 100 grams and a time period of 5 seconds is employed, but a 50-gram weight and a 1-second time period are used with liquid bitumens. Prévost Hubbard makes the following statement regarding this test:

> The penetration test is a convenient one to employ for identification and control, and is often indicative of the value of an oil or asphalt product for construction work. While the test for bituminous road materials is made in the same manner as in asphalt paving work, the standards for road purposes are somewhat different. No oil product should be employed in macadam construction with a penetration higher than 25 mm. when tested at 25°C. with a No. 2 needle for five seconds under a weight of 100 grams, unless it possesses the property of hardening considerably when subjected to the volatilization test. On the other hand, it is rarely necessary to require a penetration as high as that for asphaltic cement used in the topping of an asphalt pavement, for the reason that the upper course of a macadam road has much greater inherent stability than the sand course of the asphalt pavement. A penetration of from 10 to 15 mm. is usually considered sufficient for road work. If a material having a much lower penetration is selected, its susceptibility to temperature changes will have to be considered.

Organic matter insoluble is a term of uncertain significance which has been explained by Clifford Richardson as follows:

> On adding together the percentages of bitumen soluble in carbon disulphide and of inorganic matter obtained on ignition, the sum will seldom amount to 100.0. The difference has been considered for many years as

organic matter not bitumen (insoluble). This may be true in exceptional cases, but recent investigations have shown that it is not at all so in many bitumens. For example, in Trinidad asphalt it has been found to consist of the water of combination of the clay which the material contains and some inorganic salts which are volatilized on ignition. The amount of organic matter is extremely small. In other cases, it may consist to a considerable extent of grass and twigs, as in the seepages which have run out over sod. On the whole, therefore, it seems desirable not to describe it by any definite name, but merely as an undetermined difference.

Pure bitumen soluble in CCl_4 (carbon tetrachloride) is not usually determined unless a road oil has been badly cracked or a solid bitumen like grahamite has been added, so that the percentage of hydrocarbons insoluble in 88° naphtha is high. The bitumens insoluble in carbon tetrachloride but soluble in carbon bisulphide are called "carbenes."

Other Asphalts.—Maracaibo asphalt is found on the Limon River about 50 miles west of Maracaibo, Venezuela. According to Clifford Richardson it is an exudation from maltha springs. When carefully refined it contains from 92 to 97 per cent of bitumen soft enough to be indented by the finger nail. It contains a very small percentage of malthenes and has a higher softening point than either Trinidad or Bermudez asphalt.

Cuban asphalts are found in small quantities in many places on the island and what little use of them is made in the United States is mainly for varnishes. A deposit 18 miles from Havana has furnished material used in street pavements.

Asphaltic materials are found in many places in Mexico, and some of them have been developed more or less. What is usually known among roadbuilders as Mexican asphalt is prepared from the malthas and petroleums obtained mainly from the Tampico and Tuxpan district.

Natural asphalt has been obtained in California at several places, but the most noted deposits are no longer worked.

Refining natural asphalt consists merely in driving off the water it contains by heating the material to about 325°F. in large tanks containing coils of pipes through which steam is passed. In the bottom of the tanks are steam jets which agitate the asphalt. The vegetable impurities, if any, are skimmed from the top. The refined asphalt is drawn off while it is liquid into barrels for shipment. When it is to be used, it is melted with a residuum flux.

Solid Bitumens not Asphalts.—Gilsonite is a hard, brittle bitumen with a reddish brown streak and a conchoidal fracture, obtained mainly from Utah and Colorado. It is sold in two grades, gilsonite selects and gilsonite seconds, the former being the more pure. Gilsonite from different mines varies considerably, and some of it is of little value for use in paving mixtures.

Grahamite is a hard, brittle bitumen with a black streak, otherwise resembling gilsonite in appearance. Its softening point is very high and not yet definitely determined. It is obtained mainly from Oklahoma.

Properties of Gilsonite and Grahamite
(Clifford Richardson, *The Modern Asphalt Pavement*)

	GILSONITE		GRAHAMITE
Specific gravity, 78°/78°F.	1.044	1.049	1.171
Streak	Brown	Brown	Black
Lustre	Lustrous	Lustrous	Dull
Fracture	Sub-conchoidal	Sub-conchoidal	Hackly
Hardness	2	2	Brittle
Softens	260°F.	300°F.	Intumesces
Flows	275°F.	325°F.	Intumesces
Loss, 325°F., 7 hours	0.9%	2.3%	0.1%
Loss, 400°F., 7 hours	1.2%	4.0%	0.5%
Bitumen soluble in CS_2	99.0%	99.9%	94.1%
Insoluble organic matter	0.0%	0.0%	0.2%
Mineral matter	0.0%	0.1%	5.7%
Bitumen soluble 88° naphtha	47.2%	15.9%	0.4%
Soluble bitumen removed by H_2SO_4	87.7%	71.8%	25.0%
Total bitumen as saturated hydrocarbons	5.9%	4.5%	0.32%
Bitumen soluble in 62° naphtha	67.4%	30.3%	0.7%
Bitumen insoluble in CCl_4	0.0%	0.4%	68.7%
Fixed carbon	13.0%	13.4%	53.3%

Manjak resembles grahamite and is obtained from Barbadoes and South America. Its lack of uniformity and its high price have prevented any large use of it for American pavements, although it is used successfully in preparing other materials.

Fluxing Solid Bitumens.—Paving materials are made from solid bitumens by fluxing them with petroleum residuums by two methods. In the first method the residuum is heated to above the temperature at which the solid bitumen melts and the latter is then added. Grahamite does not melt but intumesces and the residuum to flux it must be raised to an exceptionally high temperature. The mixture is agitated until the bitumen is all melted and the combined material is of uniform quality.

In the second method, the residuum is heated to about 350°F. and air is then blown through it for six to forty hours, depending upon the quality of the old and the properties desired in the finished product. As soon as it reaches the proper consistency the blowing is stopped and enough solid bitumen mixed with it to give a paving material having the required properties.

ASPHALTIC MATERIALS FOR ROADS[1]

The selection of bituminous materials for road purposes should be based upon the local climatic conditions, the volume and character of the traffic, the character of the stone to be used, and the type of road to be constructed or maintained. Such conditions manifestly call for expert advice. The requirements of several state highway departments are given here merely as indicating the way in which specialists have met the needs of their respective localities.[2]

Some of the requirements for road oils can be met by a few crude asphaltic petroleums. Prévost Hubbard gives the accompanying analysis of a crude California petroleum of this character. This oil contained a small amount of water, and care in heating it would be necessary to prevent foaming. Hubbard says that "this oil is capable of increasing greatly in consistency after application and would serve as an excellent binding medium."

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[1] Revised by Prévost Hubbard, chief of road materials tests and research, United States Office of Public Roads.

[2] Among the engineers to whom this chapter was submitted was F. H. Joyner, Road Commissioner of Los Angeles County, California, who prepared the following comment, which illustrates forcibly the necessity of the services of a specialist in extensive road improvements:

"From a study of the notes you submitted made by my assistants and myself, and from reports of the chemist and chief road oiler, we reached the decision that our study and conclusions on what we call road oils are of value only here in California, where we use only the native oils. While there is much in the notes that would not be applicable to our California oils or asphalts, I do not believe it would be necessary or proper to propose any changes in the notes."

The following statement by W. Arthur Brown, chemist of the Los Angeles county road department, explains the views mentioned by Mr. Joyner:

"The desirable constituent of a first-class road is asphalt. The asphalt carpet coat demands an oil that contains the highest grade of asphalt. It also demands that this asphalt be thin enough to spread well. It should enter all the interstices of the road surface. When the lighter constituents of the oil have served their purpose, namely, that of carrier and distributor, they are no longer needed, in fact, they are not needed except, possibly, in very small amount. They should then be of such a nature that they will volatilise readily. We do not wish a possible volatile constituent that is solid or nearly so in cold weather but thin and acting as a fluxing agent in hot weather.

The specification of the Los Angeles county highway department is a departure from, and simpler than, the older ones requiring fixed carbon, asphaltene, viscosity, float test, loss on heating during a certain number of hours at a specified temperature, ductility test, etc. This specification requires that the oil be reduced on the Brown evaporator in a specified time. This test determines the percentage of asphalt and insures the

Crude California Petroleum Adapted for Road Work
(From Prévost Hubbard's *Dust Preventives and Road Binders*)

Character	Black, viscous, sticky.
Specific gravity 25°/25°C	0.984
Flash point, degrees C	160.0
Loss at 100°C., 7 hours, per cent	5.25
Character of residue	More viscous than crude
Loss at 163°C., 7 hours, per cent	16.4
Character of residue	Sticky, very viscous
Loss at 205°C., 7 hours, per cent	30.0
Character of residue	Solid, not brittle
Soluble in CS_2, per cent	99.77
Organic matter insoluble, per cent	0.12
Inorganic matter, per cent	0.11
Bitumen insoluble in 86° naphtha, per cent	9.8
Fixed carbon, per cent	2.05

Viscosity, mentioned in this table, is explained by Prévost Hubbard as follows:

> If it is desired to apply a road binder at a given temperature, as for instance when it is to be heated by means of steam, a determination of its viscosity at that temperature is often of value. The test also serves as a means of identification. When a viscous material is to be cut with one of lower viscosity in order to bring it to a proper consistency for application, the actual viscosity of the mixture should be ascertained and not calculated from that of the two constituents for the reason that this property is not additive.

In reporting the results of the test, the temperature of the material, the quantity used in testing, and the time in seconds taken by the material in flowing through a short tube of standard dimensions in what is called an Engler viscosimeter, are recorded. The longer the period of time taken by the material in flowing through the tube, the greater its viscosity.

The float test is employed in determining the relative consistency of very viscous materials. The results are reported in seconds of time that a float containing the material under test will remain floating in water at a stated temperature. It is considered a very useful test in controlling the preparation of road

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volatile oil being of such a nature that it will leave the oil when once it is applied on the road. The percentage of asphalt is also much nearer the actual in the oil than by the methods of heating in an oven at a lower temperature. These specifications also require a stickiness test. This stickiness test, made on the Brown adhesivemeter, when interpreted in accordance with the entire specifications, especially with the time to reduce to asphalt, determine whether the oil has sufficient binding properties to hold the particles from displacement from each other and from the base. The stickiness and loss are standardized against road oils found on the market throughout California. The results of the tests have been carefully compared with actual service results, which are in accord with laboratory results in every case so far known."

oils from given materials, for by continuing the heating until the residue gives a predetermined result in the float test, a uniform product will be obtained.

The ductility test shows the distance in centimeters that a briquette of the material will stretch before breaking, when pulled at the rate of 5 centimeters per minute. The briquette is 1 cm. square at the smallest section and has a cross-section of 2 square cm. at the clips, which are 3 cm. apart.

State Requirements for Asphaltic Materials for Penetration Roads

	ILLINOIS		OHIO	NEW YORK	PENNSYLVANIA
	Grade A	Grade B	Grade A-1	Grade A	
Specific gravity, 25°/25°C.	1.000+	0.97–1.00	0.97+	0.97+	......
Flash point, degrees C., min.	163	200	180	190	......
Ductility at 25°C., centimeters, min.	50	15	30	40	45
Penetration, 100 gr., 5 sec., 25°C., mm., min.	5–12*	5–8	9–16‡	14–19	9–15
Loss at 163°C., 5 hrs., per cent, max.	6	2	5	5	5
Character of residue	Smooth	Smooth†	§	§	......
Bitumen soluble in CS_2, per cent, min.	....	99.5	......	......	99.0
Pure bitumen products	99.5	....	99.5	99.5	......
Bermudez products	95.0	....	95.0	96.0	......
Cuban products	80.0	....	81.0	81.0	......
Trinidad products	65.0	....	66.0	66.0	......
Solubility in 86° naphtha, per cent	72–85	72–80	72–85	70–88Δ	98.5
Solubility in CCl_4, per cent	....	99.4+	98.9+	......	......
Fixed carbon, per cent	8–16	7–14	8–16	......	......

* 8–12 for material with 90 per cent total bitumen, 7–10 for material with 80 per cent to 90 per cent bitumen and 5–8 for Trinidad material having less than 80 per cent bitumen.

† Penetration of residue at least 60 per cent of that of the original material.

‡ 9–12 for pure bitumen products, 12–16 for fluxed native asphalts.

§ Penetration of residue at least half that of original material.

Δ In 76° naphtha.

NOTE—Illinois specifies a brittleness test as follows: "A cylindrical prism of the bituminous binder 1 cm. in diameter, after being maintained at a temperature of 5°C. (41°F.) for 20 minutes, shall bend 180 degrees at any point without checking or breaking." New York specifies a toughness test as follows: "It (the bituminous material) shall show a toughness at 32°F. not less than 15 cm. Toughness is determined by breaking a cylinder of the material 1¼ inches in diameter by 1¼ inches in height in a Page impact machine. The first drop of the hammer is from a height of 5 cm. and each succeeding blow is increased by 5 cm." New York also specifies a maximum of 4.7 per cent of paraffin.

State Requirements for Asphaltic Materials for Bituminous Concrete Roads

	ILLINOIS		MARYLAND	NEW YORK		OHIO		PENNSYLVANIA
	Grade A	Grade B		Grade A-1	Grade A-2	Grade A-2	Grade A-3	
Specific gravity, 25°/25°C.	1.00+	0.97–1.00	....	0.97+	0.97+	0.97+	0.97+	....
Flash point, °C., min.	163	200	300	190	190	180	180	....
Ductility at 20°C., cm., min.	50	15	20‡	25	25	30	25	50‡
Penetration, 100 gr., 5 sec., 25°C., mm., min.	5–12*	5–8	6–8.5	8–12	6–8	7–12‖	6–8	5–6.5
Loss at 163°C., 5 hrs., per cent, max.	6	2	5	4	4	5	5	3
Character of residue	Smooth	Smooth†	§	§	§	§	§	§
Bitumen soluble in CS$_2$, per cent, min.	....	99.5	....	....	....	....	....	....
Pure bitumen products	99.5	....	....	99.5	99.5	99.5	99.5	....
Bermudez products	95.0	....	....	96.0	96.0	95.0	95.0	....
Cuban products	80.0	....	....	81.0	81.0	81.0	81.0	....
Trinidad products	65.0	....	....	66.0	66.0	66.0	66.0	....
Solubility in 86° naphtha, per cent, min.	72–85	72–80	....	68–88¶	68–88¶	72–85	70–85	....
Solubility in C Cl$_4$, per cent, min.	....	....	....	....	....	98.9+	98.9+	....
Fixed carbon, per cent	8–16	7–14	....	8–17	8–17	8–17	8–17	....

* 8–12 for material with over 90 per cent of bitumen, 7–10 for material with 80 per cent to 90 per cent of bitumen, and 5–8 for Trinidad products with less than 80 per cent of bitumen.

† Penetration of residue at least 60 per cent of that of original sample.

‡ At 50 penetration and 25°C., an increase of 2 cm. required for each increase of 0.5 in penetration above 5.

§ Penetration of residue must be at least half that of original material.

¶ In 76° naphtha.

‖ 7–9 for pure bitumen products and 9–12 for fluxed native asphalts.

NOTE.—Illinois specifies a brittleness test as follows: "A cylindrical prism of the bituminous binder 1 cm. in diameter, after being maintained at a temperature of 5°C. (41°F.) for 20 minutes shall bend 180° at any point without checking or breaking." New York specifies the following toughness test: "It shall show a toughness at 32°F. not less than 10 cm. for grade A-1 and not less than 5 cm. for Grade A-2. Toughness is determined by breaking a cylinder of the material 1¼ inches in diameter by 1¼ inches in height in a Page impact machine." New York also specifies a maximum of 4.7 per cent of paraffin scale.

State Requirements for Asphaltic Materials for Surfacing

	NEW YORK		OHIO		
	Grade H. O.	Grade C. O.	Grade H. O.	Grade M. O.	Grade C. O
Specific gravity, 25°/25°C.	0.96	0.93	0.96	0.93	0.91
Flash Point, degrees C.	163	52	......	......	....
Ductility at 20°C., cm.	*	‡	......	......	....
Loss at 163°C., 5 hours, per cent.	10	30	5	25	30
Character of residue	....	....	......	......	Sticky
Bitumen soluble in CS_2, per cent.	99.5	99.5	99.5	99.5	99.5
Solubility in 86° naphtha, per cent.	75.90†	80–95†	80–94	85–97	90–98
Fixed carbon, per cent.	6–14	10	6	3.5	3
Paraffin scale, per cent.	4.7	4.0	......	......	....

* The residue after evaporation to 10 mm. penetration at a temperature not exceeding 500°F., must amount to 85 to 95 per cent of the original volume and have a ductility of at least 25 cm.

† In 76° naphtha.

‡ The residue after evaporation to 10 mm. penetration at a temperature not exceeding 500°F. must amount to 50 to 65 per cent of the original volume and have a ductility of at least 25 cm.

NOTE—New York specifies the following toughness test: Grade H. O. shall show a toughness at 32°F. not less than 20 cm. determined by the Page impact test. Ohio requires a viscosity of 10 to 60 at 100°C. for 50 cc. for Grade H. O., 40 to 80 at 50°C. for 50 cc. for Grade M. O., and 5 to 12 at 50°C. for 50 cc. for Grade C. O.

Shipping Road Oil.—Small quantities of road oil are shipped in tight wooden 50-gallon barrels, such as are used for shipping molasses, or in steel barrels. These barrels make the oil cost 2 to 3 cents a gallon more than the price for the oil itself. Uninjured empty barrels can generally be resold to the shipper. Heavy oil is troublesome to remove from barrels, and they are usually dumped into the open heating kettles and broken up. When the oil is warm the broken pieces of wood are raked out and used for fuel. If there is no heating kettle on the job, the barrels of heavy oil must be kept close to a fire or in a very warm room before the oil can be poured from them into the distributor.

Larger quantities of oil are shipped in tank cars, holding 8000 or 12,000 gallons. Where a large amount of oil is to be used annually near any railway, it will be desirable for the officials to supply a tank into which the oil can be run as soon as the car arrives. The season for roadwork is limited and during it there is a brisk demand for tank cars. The oil company which loses the service of a car for a week or ten days, while it stands on a siding waiting to be emptied, is obliged to add an equivalent item to its overhead expense, and the road district which provides for prompt discharge of tank cars is in a position to demand,

and will probably get, quotations shaded somewhat to recognize its sense of business fairness.

If oil must be used hot, a ¾ or 1-inch steam connection must be made with the heating coils of the tank car. For this reason, the car is often spotted on a siding near an electric station or mill, but the steam can also be furnished by a road roller, traction engine or other convenient source. It will take from twelve to twenty-four hours to heat a tankful of heavy oil to 150° to 170°F., which is high enough to allow it to be pumped. The temperature can be increased after that in the distributor. The amount of steam supplied to the heating coils of the car is regulated by a valve on the exhaust pipe of the coil, which is adjusted to prevent a waste of steam. As some road oils have a low flash point, great care must be taken to prevent any oil coming in contact with a flame. The temperature of the oil should be tested from time to time with a thermometer, to see that it is not overheated. If there is any water in the oil it will give a great deal of trouble if heated quickly, and if foaming is detected the rate of heating should be checked at once.

Specific Gravities, Degrees Baumé, Weights in Pounds per Gallon and Volume in Gallons per Pound of Oils at 60°F. Having Specific Gravities Exceeding 1.00

SPECIFIC GRAVITY	DEGREES BAUMÉ	POUNDS PER GALLON	GALLONS PER POUND	SPECIFIC GRAVITY	DEGREES BAUMÉ	POUNDS PER GALLON	GALLONS PER POUND
1.00	0.00	8.328	0.1201	1.15	18.91	9.577	0.1021
1.01	1.44	8.411	0.1189	1.16	20.00	9.660	0.1009
1.02	2.84	8.495	0.1177	1.17	21.07	9.744	0.0997
1.03	4.22	8.578	0.1165	1.18	22.12	9.827	0.0985
1.04	5.58	8.661	0.1153	1.19	23.15	9.910	0.0973
1.05	6.91	8.744	0.1141	1.20	24.17	9.994	0.0961
1.06	8.21	8.828	0.1129	1.21	25.16	10.077	0.0949
1.07	9.49	8.911	0.1117	1.22	26.15	10.160	0.0937
1.08	10.74	8.994	0.1105	1.23	27.11	10.243	0.0925
1.09	11.97	9.078	0.1093	1.24	28.06	10.327	0.0913
1.10	13.18	9.161	0.1081	1.25	29.00	10.410	0.0908
1.11	14.37	9.244	0.1069	1.26	29.92	10.494	0.0889
1.12	15.54	9.327	0.1057	1.27	30.83	10.577	0.0877
1.13	16.68	9.411	0.1045	1.28	31.72	10.660	0.0865
1.14	17.81	9.494	0.1033	1.29	32.60	10.743	0.0853

NOTE: For a similar table of oils of specific gravities less than 1.00 see page 358.

Pumping Road Oil.—In order to remove the oil from the tank car to the distributors, some form of pump is generally necessary, for it is not often that the car can be placed on a siding or trestle high enough to allow it to be emptied by gravity.

If a lift pump set in the top of the car is used, it should be a 3 or 4-inch size. With it one man can fill a 600-gallon distributor in twenty minutes.

In many cases a hose or pipe is connected to the bottom of the car and run to an oil pump, operated by a steam or gasoline engine, which forces the oil into the distributor. A 1½ or 2-inch power-driven rotary pump will deliver 600 gallons in ten to fifteen minutes. These pumps work with either hot or cold oil. A water tank pump can be used with cold oil but hot oil will ruin the valves speedily. A 2-inch suction tank pump will fill a 600-gallon tank in thirty to forty minutes.

The hose used in the connections between the pump and the bottom of the tank car should be as short as possible because the oil often destroys it rapidly. It is desirable to have a cut-off valve in the connection pipe. When everything is coupled ready for use, the discharge valve in the bottom of the car is raised by means of a vertical stem running up to the dome of the car, and the flow of oil is controlled by the cut-off valve, for the manipulation of the tank valve is quite troublesome.

Heating Road Oil.—As the fixed and operating charges at an oil storage plant are about the same irrespective of the amount of oil delivered into distributors, it is desirable to load as many carts daily as practicable, in order to reduce the unit cost of such work. In California, where large amounts of oil are used in surfacing concrete roads, oil stations have been designed with particular attention to effecting such economics. It is considered desirable to have the oil at a temperature of 300° F. when it is applied, so it is heated to 325° for delivery within 10 miles and 350° for longer deliveries.

The oil is discharged from the cars into storage tanks or pits holding 10,000 to 25,000 gallons. These contain steam coils to warm the oil sufficiently to enable it to be pumped into a circulating tank holding 2000 to 3000 gallons, where it is heated further by steam coils. The oil is then pumped through a heater and back into the circulating tank until its temperature is about 200°, after which the temperature of the heater is raised and the oil pumped through it into the distributor. The whole operation takes one and one-half hours.

The heater resembles a return tubular boiler. The furnace has a fire brick arch and walls and is heated by oil burners. The heated gases pass over the furnace arch in a chamber formed of ordinary brick masonry, and finally escape through a steel stack. The oil is pumped through a multiple grid of 3-inch pipes. The design is made on the assumption that with furnace temperatures of 1800° to 2000°, 1 square foot of heating surface will transmit 3 British thermal units per hour per degree of change in temperature.

Volume of Oil at 60°F. Equivalent to Unit Volume at Stated Temperatures in Fahrenheit Degrees

0°F	0	10	20	30	40	50	60	70	80	90
......	......	......	......	......	......	......	1.000	0.996	0.992	0.988
100	0.984	0.980	0.977	0.973	0.969	0.965	0.962	0.958	0.954	0.951
200	0.947	0.943	0.940	0.936	0.933	0.929	0.926	0.922	0.919	0.916
300	0.912	0.909	0.906	0.903	0.899	0.896	0.893	0.890	0.886	0.883
400	0.881	0.877	0.875	0.871	0.868	0.865	0.862	0.859	0.856	0.853

NOTE: This table is based on the assumption that the volume of oil increases 0.4 per cent for every increase of 10°F. above 60°. This rule is exactly applicable only to some oils. In Los Angeles County, Cal., the rate of increase in volume is taken at 0.3 per cent in the specifications of the county road department.

Purchasing Oil.—Oil increases in volume from 0.3 to 0.4 per cent for each 10°F. rise in its temperature. The oil is bought on the basis of its volume at 60°F. and if measured at any other temperature its volume must be computed, or, in the case of an oil having an increase in volume of 0.4 per cent per 10°F., the accompanying table will give the volume at 60° with a minimum amount of figuring. To use it, multiply the tabular number for the temperature at which the measurement was made by the measured quantity of oil. For example 1,100 gallons of oil at 375°F. multiplied by 0.888 gives 978 gallons as the volume at 60°F. If the rate of increase per 10°F. was 0.3 per cent, the volume at 60°F. would be 995 gallons.

TAR AND TAR PRODUCTS[1]

The tar used in roadbuilding is obtained by refining the crude tar produced in the destructive distillation of coal, in making enriched water gas and in certain classes of coke ovens. It is a complex mixture of many hydro-carbons and is not a simple chemical substance.

In a city gashouse, gas is produced by heating coal in retorts usually about 8 feet long, 15 inches high and 18 inches wide. The tar is driven off with the gas and is collected for the most part in "hydraulic mains" which act as water seals for the gas. The gas is further cooled in a condenser, where more tar is deposited, and the remaining tar is removed in a tar extractor and scrubbers. The tar obtained at each stage in the process is different from that obtained at the other stages, but all of it is usually run into large wells, where the accompanying ammoniacal water rises and is drawn off. The character of the tar varies greatly. It is much affected by the temperature at which the coking is conducted, as well as by the character of the coal used. High temperatures result in an increase in the amount of free carbon in the tar, and this increase in free carbon is accompanied by an increase in specific gravity. The presence of ammoniacal water with oils distilling below 110°C. is stated by Prevost Hubbard to be the distinguishing features of all crude coal tars.

Another class of tar is obtained from by-product coke ovens. The retorts in this case are much larger but are operated in much the same way as the retorts of illuminating gas plants, except that the main endeavor is to produce the maximum amount of coke instead of gas. For this reason the temperatures are lower than those usually employed in coal-gas works and the tar is likely to have a comparatively low amount of free carbon and a comparatively high amount of oils. There are several types of by-product coke ovens, and some produce tars better suited for road work than other types.

Water gas is made by passing steam over hot coal, in which process no tar is produced. This gas is a mixture of hydrogen and carbon monoxide, and burns with a flame of no value for illumination. It must therefore be mixed with hydrocarbons, which are usually obtained by cracking a grade of petroleum distillate called gas oil. In the purification of this enriched or "carburetted" gas, tar is obtained which is called water-gas tar. It is lighter than coal tar and the water it contains is practically free from ammonia, which is an identifying characteristic of this material. It has a comparatively high amount of heavy oil and a low amount of pitch.

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[1] Revised by Prevost Hubbard, Chief of road materials tests and research, U. S. Office of Public Roads.

In some gas works both coal gas and water gas are made and the tar from both processes are collected together, resulting in mixtures which may vary greatly in composition.

The crude tar is stored in tanks at the refineries, each class by itself. As much water is removed by settling as is possible, since this is the cheapest method of getting rid of it. After settling, the tar is pumped into a still. Sometimes the tars from several sources are mixed so that a product with certain characteristics can be obtained which are unattainable by refining tar from one source. The stills are set in brick like horizontal boiler shells and are heated very carefully at first to prevent the water in the tar from causing foaming. The vapors from the still are liquified in condensers. Water and light oils are first driven off, then intermediate oils and finally heavy oils. The road materials are obtained from the residuum. The distillation must be stopped early if a light road tar is desired, while the process is carried much further if a binder is desired. In the final stages, the contents of the still are agitated by jets of air to prevent coking.

The composition of several crude tars and of the heavy pitches made by refining them is given in the accompanying table. The figures must not be considered more than representative of general characteristics, for individual tars in the same class vary greatly.

Tar products for road purposes are called "straight-run" when they are the residuums left after refining crude tars to the degree which will furnish a material of suitable composition, and "cutback" when they are made by fluxing a hard pitch with a lighter distillate.

The effect of free carbon in tar upon its utility for road purposes has been a subject of protracted controversy. Philip P. Sharples makes this comment:

> Experience has seemed to settle that a moderate amount of free carbon is beneficial in a road tar, thus bearing out the practical experience gained in the use of coal tar materials in other directions. At the same time, an excess of free carbon is not desirable, since it tends to make the material difficult to work and also reduces to a considerable degree the amount of true bitumen available. On the other hand, a certain percentage of free carbon seems to enhance the binding power of the refined tar. The upper

Characteristics of Crude Tars and Their Residual Pitches

(From Philip P. Sharples)

	HORIZONTAL GAS, 16TH STREET, NEW YORK		HORIZONTAL GAS, ASTORIA, N. Y.		INCLINED GAS, ASTORIA, N. Y.		COKE OVEN,[2] LEBANON, PA.		VERTICAL GAS, PROVIDENCE, R. I.		WATER GAS, RAVENSWOOD	
	Tar	Pitch	Tar	Pitch	Tar	Pitch	Tar	Pitch	Tar	Pitch	Tar	Pitch
Specific gravity, 15.5°C.	1.293	1.357	1.267	1.306	1.238	1.284	1.187	1.281	1.153	1.225	1.074	1.190
Free carbon, per cent	37.5	46.1	28.9	33.5	24.3	30.4	10.8	19.3	4.0	10.4	0.3	1.1
Viscosity, Engler, 100°C.	30.0		21.8		14.9		3.0		2.1		1.6	
Melting point, degrees F.		127		131		130		133		145		139
Oil[1] per cent			13.2		14.3		21.8		28.8		45.1	
Fixed carbon, per cent		51.5		42.0		37.9		28.8		19.1		23.8
Tar acids in oil, per cent			14.0		21.0		4.0		29.0		0.0	
Ash, per cent		0.4		0.21		0.10		0.48		0.23		0.06

[1] Amount of oil produced when the tars are distilled to a soft pitch.

[2] Semet-Solvay ovens. Concerning this type Prevost Hubbard makes the following comment: "The low percentage of free carbon is characteristic of the Semet-Solvay coke oven tars, which usually carry from 3 to 10 per cent of this constituent. The Otto-Hoffman ovens produce higher carbon tars as they are fired at a higher temperature."

NOTE.—"It will be noted that there is a great difference in specific gravity, the specific viscosity, and the percentage of free carbon, and that these vary in somewhat the same way. While this accord in the variations is marked in the type of samples taken, it is not inversely true, and we may have samples in which the variations would not fall in the same place in the different columns, although there are no very marked diversities. The amount of oils produced when the tars are distilled to a soft pitch varies inversely. This is also subject to individual variations, although the general quantities yielded vary as indicated. In the tar acids produced, however, it will be noted that the different tars show no gradual variation. The one marked feature of this line is the absence of tar acids in the water-gas tar oil; but even here samples may be found which have small percentages of acid. It is also possible to obtain coke-oven tars which contain a large percentage of tar acid."—*Philip P. Sharples.*

Specifications of Several State Highway Departments for Tar Products for Different Classes of Road Work

	NEW JERSEY				NEW YORK					
	Coal tar		Water gas tar		High carbon			Low carbon		
	N	M	UA	U2	Binder	H.O.	C.O.	Binder	H.O.	C.O.
Specific gravity	1.12–1.18	1.22–1.30	1.09–1.12	1.14–1.17	1.2+	1.19+	1.14–1.18	1.16+	1.14+	1.10–1.13
at degrees C.	15.5	15.5	25	25	25	25	25	25	25	25
Float test, seconds	....	120–150	....	16–20	....	18–28	....	....	15–25	....
at degrees C.	....	50	....	100	....	....	....	....	100	....
Viscosity	150–300[1]	....	60–100	....	....	....	125[3]	....	....	125[3]
Free carbon, per cent	4–12	15–25	3	3	12–25	10–22	4–12	5	4	2
Distillation, per cent	....	....	....	....	....	....	....	....	....	....
to 170°C., maximum	7	0.1	3	1	0	0	5	0	1	5
170°–235°C., maximum	....	....	20	5	3	10	18	5	12	20
235°–270°C., maximum	35	15	37	15	12	16	25	15	20	28
270°–300°C., maximum	....	....	50	30	16	20	32	20	25	25
Specific gravity of distillate at 15.5°C.	1.01	1.03	....	....	1.03[3]	1.03[2]	1.01[3]	....	....	....
Melting point of residue, degrees C.	75	75	60	65	75	75	70	75	75	70
Melting point, ball and ring, degrees C.	....	....	....	....	27	....	....	27–34	....	....

	PENNSYLVANIA				OHIO					ILLINOIS
	High carbon		Low carbon		High carbon		Low carbon			
	Binder	C, oil	Binder	C, oil	Binder	H.O.	C.O.[7]	Binder	H.O.	Binder
Specific gravity	1.2	1.14–1.18	1.15–1.175	1.10–1.13	1.2–1.27	1.18–1.25	1.0–1.18	1.16–1.20	1.14	1.26
at degrees C	15.5	15.5	25	25	25		25		25	25
Float test, seconds			20–24		120–180	120–180		150–210	120–180	120–180
at degrees C			100		50	32		50	32	50
Viscosity		200–300[1]		180–280[6]			6–15[9]			
Free carbon, per cent	12–25	4–12	3	3	10–22	10–20	4–12	10	8	22
Distillation, per cent										
to 170°C., maximum	0	7	0.5	2	0	1	5	0	1	5[9]
170°–235°C., maximum		35	3	18	10	16	28	10	20	
235°–270°C., maximum			12	33						
270°–300°C., maximum			25	43	20	24		20	25	15[10]
Specific gravity of distillate at 15.5°C		1.01			1.03[2]	1.03[2]		1.00[2]	1.00[2]	
Melting point of residue, degrees C	74[4]	65			75	75	70	75	75	
Melting point, ball and ring degrees C	37–43[5]		65	60						

[1] At 40°C. first 100 cc.

[2] At 25°C.

[3] At 60°C.

[4] Residue after carrying distillation to 315°C.

[5] Determined by ½-inch cube method.

[6] First 50 cc. at 40°C.

[7] This tar may contain not over 1 per cent of water.

[8] First 50 cc. at 50°C.; specific viscosity.

[9] The distillate to 110°C. must not exceed 2 per cent.

[10] To 315°C.

Note.—New Jersey limits the naphthalene in the distillate of water gas tars to 2 per cent, and specifies a loss on evaporation of 28 and 12 per cent of grades UA and U2 respectively. Illinois requires a cylinder of tar 1 cm. in diameter, after remaining at 0°C. for twenty minutes, to bend into a semicircle of 3 cm. diameter, without checking or breaking.

limit may perhaps be set at 25 per cent for a binder and perhaps 22 per cent for a tar used for hot surface application. The lower limits on these classes of materials should certainly not be less than 12 per cent for binder materials and 10 per cent for hot surfacing materials. With cold surfacing materials the free carbon is necessarily much lower, as its presence in large quantities reduces the penetration. With cold surfacing materials 4 per cent may be placed as a desirable minimum.

Prevost Hubbard makes the following comments on free carbon in his Dust Preventives and Road Binders:

> In tars of the same consistency, those of low carbon contents have a greater inherent binding strength than those of high-carbon contents. In tars whose bitumen contents are of the same consistency those of high carbon contents have a greater inherent binding strength than those of low carbon contents, but the binding capacity of the former is lower. In sand-tar mixtures containing a relatively large amount of high carbon tar, the carbon may act as a filler and add to the mechanical strength of the mineral aggregate, but better results in this respect can be obtained by the use of a smaller quantity of low carbon tar of the same melting point, together with a mineral filler. The waterproofing value of high-carbon tars is in general less than that of low-carbon tars. Free carbon retards the absorption of tars by porous surfaces. When tar is exposed in comparatively thin films free carbon has little or no effect in retarding volatilization.
>
> Applying these facts to the use of tar in road treatment the following conclusions are logically deduced: (1) In the treatment of old road surfaces a low carbon tar is to be greatly preferred to a high carbon tar. (2) In ordinary bituminous road construction, both from the standpoint of efficiency and economy, a low-carbon tar is to be preferred to a high-carbon tar whose bitumen content is of the same consistency.

The distillation test of tars furnishes information regarding their utility for road work. Formerly the test was made on material which might or might not contain water, but the tendency of specialists at present is to remove any water from the samples by preliminary distillation at a low temperature, for no water is permitted in tar for hot application under most specifications now. The distillation is carried on in an Engler flask and is conducted in a series of stages. The terminal temperatures of the stages have usually been 110°C., 170°C., 270°C. and 300°C., but recently it has been proposed to make another stage with a terminal temperature of 235°C. The test is one which must be conducted with careful observance of the procedure specified for the method followed or the results will not be comparable. The distillate obtained during each stage is called a "fraction."

The 1916 requirements of several State highway departments for different grades of tar are given in an accompanying table.

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- Texaco Special Macadam Binder
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BITUMINOUS ROADS[1]

Bituminous materials are used on gravel and broken stone roads in three ways: (1) thoroughly mixed with the stone or gravel before the latter is placed on the roads; (2) driven into the interstices between the stone after the latter has been placed on the road; (3) applied to the surface of a finished gravel or broken stone road. The first method produces what is now commonly called bituminous concrete and the second method bituminous macadam. These will be described in this section and surface applications will be described in the next section.

Rock for Bituminous Roads.[2]—In bituminous road work observations indicate that in some cases it is advantageous to use a rock of relatively high absorption rather than one with low absorptive qualities, owing to a better adhesion of the bituminous material by a partial surface impregnation of the rock.

While the binding or cementing value of a rock is a most important consideration from the standpoint of ordinary macadam construction, the same is not true of broken-stone roads which are carpeted or constructed with an adhesive bituminous material. The French coefficient of wear is also of relatively less importance, owing to the fact that the fine mineral particles produced by the abrasion of traffic combine, or should combine, with the bituminous material to form a mastic which is held in place and protects the underlying rock from abrasion so long as it is kept intact by proper maintenance. The toughness of the rock is of more importance, as the shock of impact is to a considerable extent transmitted through the seal coat and may cause the underlying fragments to shatter. It would, therefore, seem that the minimum toughness of a rock for use in the construction of a bituminous broken-stone road or a broken-stone road with a bituminous-mat surface should, for light traffic, be no less than for ordinary macadam subjected to the same class of traffic. For moderate and heavy traffic, however, the same minimum toughness should prove sufficient, owing to the cushioning effect of the bituminous matrix. No maximum limit of toughness need be considered for any traffic.

---

[1] It is the purpose of this chapter to indicate the methods followed in several sections of the country where bituminous roads have been built extensively rather than to recommend any methods as the best for all conditions. Revised by P. St. J. Wilson, chief engineer, United States Office of Public Roads and Rural Engineering; F. H. Joyner, road commissioner of Los Angeles County, Cal.; and W. R. Farrington, division engineer, Massachusetts Highway Commission.

[2] From Bulletin 370, United States Department of Agriculture, "Physical Tests of Road-Building Rock," by Prevost Hubbard, chemical engineer, and Frank H. Jackson, Jr., assistant testing engineer, Office of Public Roads.

In the case of bituminous concrete roads, where the broken stone and bituminous material are mixed prior to laying and consolidation, it generally appears advisable to set a minimum toughness of 6 to 7 for light-traffic roads, instead of 5, in order to insure that the fragments of rock which have been coated with bitumen shall not be fractured under the roller during consolidation; and 12 or 13 for moderate and heavy traffic, instead of 10 and 19, as in the case of water-bound macadam roads.

Bearing in mind the fact that availability, cost, and various local conditions generally control the selection of proper limits, the accompanying table may be used as a general guide for minimum limits of the French coefficient of wear and toughness in connection with bituminous broken-stone roads.

Bituminous Materials.—Climatic conditions, the volume and character of traffic to be carried by a road, the kind of stone to be used, and the methods of construction vary greatly in different places and have an important influence on the determination of the bituminous materials to be used. For this reason it is not practicable to have a general specification of universal applicability. The requirements for bituminous binders of a number of states are given in the tables on pages 373, 374 and 382.

In most cases the binders are furnished by the contractors under specifications of greater or less detail. In Massachusetts the State highway commission usually purchases its material and furnishes it to the contractors, although contractors are occasionally required to supply it.

Bituminous Macadam.—Roads of this type are frequently said to be built by the "penetration" method because the bituminous material is made to penetrate the interstices of the road from the surface. The grading, drainage and rolling of the subgrade are carried out as in the case of waterbound macadam roads. On the subgrade is laid a base or bottom course, then a top course to which the bituminous material is applied, and finally a thin "seal" coat of bituminous material covered with screenings or gravel to protect the main mass of the road from the weather and other deteriorating influences.

The depth of the bottom course varies with the character of the subgrade, the traffic, the quality of the stone, the character of the top course and the preferences of the highway authorities. Probably 6 inches at the center and 4 inches at the sides are

Limits of Physical Tests of Rock for Bituminous Roads
(Recommended by Prévost Hubbard and Frank H. Jackson, Jr.)

	LIGHT TO MODERATE TRAVEL			MODERATE TO HEAVY TRAVEL		
	French coefficient	Percentage of wear	Toughness	French coefficient	Percentage of wear	Toughness
	At least	*Not over*	*At least*	*At least*	*Not over*	*At least*
Broken stone with bituminous carpet................	5	8	5	7	5.7	10
Bituminous macadam · with seal coat......	5	8	5	7	5.7	10
Bituminous concrete.	7	5.7	7	10	4	13

Gallons of Bituminous Material per Mile of Road for Different Rates of Application

GALLONS PER SQUARE YARD	WIDTH OF ROAD IN FEET						
	9	10	12	15	18	20	22
0.20	1,056	1,174	1,408	1,760	2,112	2,347	2,582
0.25	1,320	1,467	1,760	2,200	2,640	2,933	3,227
0.33	1,742	1,936	2,323	2,904	3,484	3,872	4,259
0.40	2,112	2,347	2,816	3,520	4,224	4,694	5,163
0.50	2,640	2,934	3,520	4,400	5,280	5,867	6,454
0.60	3,168	3,520	4,224	5,280	6,336	7,040	7,744
0.67	3,538	3,931	4,716	5,896	7,075	7,862	8,648
0.70	3,696	4,107	4,928	6,160	7,392	8,214	9,035
0.75	3,960	4,400	5,280	6,600	7,920	8,801	9,680
0.80	4,224	4,694	5,632	7,040	8,448	9,387	10,326
0.90	4,752	5,280	6,336	7,920	9,494	10,561	11,616
1.00	5,280	5,867	7,040	8,800	10,560	11,734	12,907
1.25	6,600	7,334	8,800	11,000	13,200	14,668	16,134
1.50	7,920	8,801	10,560	13,200	15,840	17,601	19,361
1.75	9,240	10,267	12,320	15,400	18,480	20,535	22,587
2.00	10,560	11,734	14,080	17,600	21,120	23,468	25,814

average depths.[1] In Massachusetts, where the foundation is prepared very carefully, sometimes consisting of 12 inches or more of gravel or telford, an 18-foot roadway usually has a bottom course 2 inches thick at the sides and 3 inches thick at the center, after rolling, except on stone foundations, where the standard thickness is 2 inches at all points of the cross-section. These thicknesses are increased in some cases.

The Massachusetts specifications call for smaller stone than those of most states, and give the engineer the final decision regarding the proportions of the ½ to 1¼-inch size and the 1¼ to 2½-inch size which shall be mixed together for this course, the intention being, where stone is crushed locally, to vary these proportions in order to use the output of the crusher. In New York and Pennsylvania the maximum size of the stone for this course is 3½ inches. The Pennsylvania specifications require the stone to have a French coefficient of wear of not less than 10, and permit the use of gravel and of broken slag which weighs 70 pounds or more per cubic foot, measured loose. In Ohio, if sandstone is used in the bottom course, pieces as large as 6 inches are permitted; the maximum size with other rocks is 4 inches. In Illinois and California the maximum size is 3 inches. These variations are due mainly to differences in the average quality of stone available in the different states.

---

[1] On roads where the traffic promises to be heavy, it is often considered best to have the same depth the entire width of the road.

After the stone has been spread, it is sometimes harrowed. The Illinois specifications call for the use of a tooth harrow weighing 10 to 12 pounds per tooth. The course is then consolidated with a roller, one weighing 10 tons or more being generally required. It is next covered with screenings, small gravel and sometimes coarse sand, which are broomed and rolled dry until the interstices are filled, but not over-filled. Some engineers consider the course finished at this stage, while others require it to be sprinkled with water and rolled so as to consolidate it still further.

On the work under a number of State highway departments, the stone for both the top and bottom courses must be shoveled from the carts into place, or be dumped on platforms and shoveled from there into place, or be spread over the road by distributing wagons built for the purpose. In other states the stone for the bottom course may be dumped on the subgrade and shoveled from these piles into its final place. Stone for the top course is never permitted to be dumped in piles on the bottom course. The screenings or other fine material used on the road are generally required to be delivered along the road before construction begins.

Other types of bottom courses than those made of graded aggregates are occasionally used. Many macadam roads in good condition have had a bituminous macadam top course put on them. Macadam roads when in poor condition are often scarified, new material added where needed, and then rolled, thus furnishing a suitable bottom course at minimum expense. If these old roadways are thus used, their drainage should be carefully examined and all defects remedied before the top course is laid. In the New York state highways, a base of run-of-bank gravel not larger than 3½ inches is sometimes used. In this case the material passing a ¼-inch screen must not be more than 5 per cent in excess of the voids in the remainder of the material after this fine stuff has been removed.

In Massachusetts the top course is usually 2 inches thick, and as stone from 1¼ to 2½ is required the largest pieces become imbedded slightly in the bottom course by the rolling. More than 15 per cent of the ¾ to 1¼-inch stone, which is permitted in the bottom course, is not desired in the top course because experience has convinced the Massachusetts engineers that its presence makes a less durable road. More bituminous binder is required with coarse than small stone, but the entire quantity can be applied at one time, while if small stone is used it has been found desirable to construct this course in two layers in order to be certain that the smaller voids existing with such stone are filled.

The top course in most States is usually from 2 to 3 inches thick.

The top course of the New York State highways is made of 1¼ to 2½ inches stone, in Pennsylvania 1 to 3-inch, in Ohio 1½ to 2½-inch stone for a course less than 3 inches thick and 2½ to 4-inch stone for a course 3 inches or more thick, unless the stone has a loss on abrasion of less than 6 per cent, when the size is reduced to 2 to 3½ inches; in Illinois 1 to 2¼ inches. The Ohio and Illinois specifications require it to be harrowed.

In rolling this course, it is usually considered desirable to roll adjacent strips of the shoulders as well, so as to unite the shoulder and roadway as completely as practicable. It is also generally considered desirable to roll the stone until it is "locked" in place so the binder distributor can pass without leaving any impression, but not to the maximum density. The reason for this is that the bituminous material is believed to be more uniformly distributed if the course of stone is capable of further compression after the binder has been applied. Some stone hard enough to carry travel should not be rolled heavily, for if heavily rolled the voids will be so reduced that the binder will not penetrate into them properly.

No bituminous material should be applied except when the stone on the surface is clean and free from dust. The application is now made in many cases with a pressure distributor, which is required by some State highway departments; it is also applied by gravity distributors and, on small work, by hand pouring cans.

Distributing wagons often have some kind of fire-box for keeping the binder hot. Gravity distributors discharge their contents through nozzles or other spraying devices at their rear about 12 inches above the road. The shape and location of the nozzles are so selected that the binder will be distributed uniformly over a strip of the road somewhat wider than the distance between the wheels. The binder flows from the nozzles by gravity, and as the contents of the tank are drawn off the pressure on the nozzles decreases and the rate of flow per minute is reduced. In order to maintain a uniform flow, a control valve in the outlet pipe is provided. The rate of application of the material is regulated by this valve and the speed of the distributor.

Pressure distributors are used where it is desired to have better control over the rate of application of the binder than is practicable with gravity distributors, and also to obtain the best distribution and penetration. In some types, compressed air or steam is admitted to the top of the tank so that the pressure on the surface of the binder, whether the tank is full or almost empty, is sufficient to drive the material through the nozzles with considerable force. In other types, the binder is driven out of the nozzles by a small pump. The nozzles of the pressure distributors are generally about 6 inches from the surface of the road. In some cases the binder is forced through a hose ending in a nozzle which the operator moves along just above the surface of the road.

Bituminous material is also distributed from tank wagons without any suitable piping and nozzles of their own. This is done by attaching to their rear end a light two-wheel sulky having the necessary distributing apparatus, which is connected by piping with the outlet of the tank wagon. Attachments are also made for this purpose which can be bolted to an ordinary tank wagon.

Pouring cans resemble garden watering cans in appearance. The top is usually partly covered to prevent the binder from slopping out, and there is generally a removable screen which intercepts anything likely to clog the nozzle. The nozzle is a slot 6 to 10 inches long, which is usually adjustable. A skillful man can apply bituminous material in this way very uniformly, but the expense on large work is greater than with distributors.

The binder can be heated in portable kettles, usually mounted on wheels, in distributing wagons, oil heating pits, or in tank cars, the method to be followed depending upon the amount of material to be heated.

The amount of binder used is from 1¼ to 1¾ gallons per square yard, depending upon the depth and size of the stone. If an asphalt binder is used it must be applied at a temperature of about 300°F. and if tar at about 200° to 225°F. After it is spread it is covered with small stone, usually from about ¼ to ¾ inches in size; in New York State work stone of ⅝ to 1¼ inches is specified. In Massachusetts good results have been obtained in some cases with sand. After this dressing has been spread it is often gone over with brooms to make certain that all voids in the surface are filled, and the material unformly distributed, and the brooming should be finished with the brooms working parallel with the line of the road.

After the top course has become firm under the roller, the surface is swept clean and the seal coat is applied. This is usually spread at the rate of ⅓ to ¾ gallon per square yard, and is covered with ¼ to ¾-inch stone chips or pea gravel. The road is then broomed, using a lock street broom for the purpose, and then given a thorough rolling as to consolidate it as much as possible and the broom can be attached to the roller during this final rolling. A liberal use of both the hand broom and the lock street broom, or the broom fastened to the roller, during the screening and finishing of the road will do much to insure that the dressing is evenly taken up by the oil and a smooth riding surface obtained that will not start the pounding of automobiles and the consequent rippling of the surface.

In the State highway work of Illinois, there are there courses and a seal coat in bituminous macadam construction. The second course is 1 to 2¼-inches stone, harrowed, rolled, and treated with 1 gallon of binder per square yard. This is covered with ¼ to ½-inch screenings, which are broomed into the voids and the excess swept off. A second application of binder is then made at the rate of ½ gallon per square yard and covered with torpedo gravel ranging in size from ⅜-inch down to fine sand. This is broomed until the voids are filled, when the surplus is removed. Another application of binder is made at the rate of ½ gallon per square yard and covered with torpedo gravel at the rate of about 1 cubic yard per 200 square yards of road. The wheels of the roller may be wet to prevent them from picking up the binder; some engineers object to such wetting and require the wheels to be oiled.

Where the grade is steep, the Massachusetts highway commission has recently tried the practice of leaving the surface rather rough, so as to afford a foothold for horses and resistance to skidding for automobiles.

Bituminous Concrete.—When the stone and binder are mixed together thoroughly before they are placed on the road, it is practicable to use both small and large stone and thus reduce the volume of the voids to be filled with bituminous binder. This material is placed on any of the bottom courses used with bituminous macadam and also on concrete. It is essential for the bottom course to be dry and clean when the mixture is spread over it.

The size of the stone required by different State highway departments varies somewhat, and some departments have a number of standard proportions. In Massachusetts crusher-run trap from ¼ to 1½ inches is specified for some roads, and also crushed gravel, which will be mentioned later. In New York, ⅝ to 1¼-inch stone is used for a course 2 inches or less in thickness, and for thicker courses stone up to 2¼ inches in size is allowed. In both New York and Maryland materials are permitted which will give a finished pavement with less than 10 per cent passing a 2-mesh screen, 8 to 22 per cent passing a 4-mesh, 25 to 55 per cent passing a 10-mesh, 18 to 30 per cent passing a 40-mesh, 5 to 11 per cent passing a 200-mesh, and 7 to 11 per cent of bitumen. In Maryland a mixture is also used containing two parts of ¼ to 1½-inch stone and one part of sand with 25 per cent passing a 20-mesh screen and 5 per cent passing 80-mesh. To this mixture is added 5 per cent of powdered limestone or cement and 7 to 9 per cent of bitumen. In Illinois the proportions are left to the engineer, but the purpose is to obtain the equivalent of a thorough mixture of 1 cubic yard of grit sand passing a ⅜-inch ring with 40 to 80 per cent passing a 10-mesh sieve, and 3 cubic yards of ¾ to 1½ inch stone with 30 to 80 per cent retained on a 1-inch ring. Instead of the stone 3 cubic yards of ⅜ to 1-inch gravel with 20 to 70 per cent retained on a ⅜-inch screen may be used.

The amount of bituminous binder on the Massachusetts work is about 20 to 24 gallons per cubic yard of stone. In New York, for the work with broken stone without fine material, 18 gallons are used per cubic yard of stone and the purpose is to have the finished course contain from 5 to 7½ per cent by weight of bitumen. On the Illinois work, from 27 to 30 gallons of binder containing 95 per cent or more of bitumen is used per cubic yard of stone or gravel, and if the binder contains less than 95 per cent of bitumen the quantity must be increased proportionately.

Although stone and tar binder have occasionally been mixed cold, as in Rhode Island, it is customary to mix the stone and bituminous material hot. There is a marked difference of opinion regarding the temperature to which the stone should be heated, Massachusetts requiring this to be 180°F. or more and Illinois 300° to 375°. A high temperature will injure some binders and not others, and it is therefore important to have the aggregate uniformly heated to the proper temperature for the binder used, the weather conditions, and the length of haul from the mixing plant to the road. The binder is heated in kettles or tanks. The temperature for asphalt is 275° to 375° and for tar 200° to 275°, the limits varying somewhat with the grades used. Special care must be taken to prevent overheating. Sometimes hot stone and cold binder are mixed. The mixing on small work can be done by hand, but is more quickly and thoroughly performed on large work in mixers made for the purpose.

The best equipment for any contract will depend upon local conditions, among which the transportation of the mixed material is an important factor. The mixture must be delivered on the site at temperatures of 150° to 280°, according to the binder used. The maximum permissible drop between the temperatures of the material at the mixer and when it reaches the road, freedom from segregation in the mixture, and the practicable speed of delivery, fix the maximum length of haul. If the maximum length of haul permits the use of a central plant for the whole work, it is often practicable to locate it at the crusher plant and save some labor charges. Portable plants for use along the road have been greatly improved in recent years and are used extensively.

The wagons for transporting the mixture should be tight, and under some weather and hauling conditions their contents should be covered with canvas to keep them from becoming chilled. The bodies of motor trucks are sometimes jacketed or insulated for the same purpose.

The mixture should be shoveled from the wagons, or dumped on wood or metal platforms from which it can be shoveled. The shovels are often heated, as are the rakes used in spreading the mixture. It is considered desirable by some engineers to prohibit delivering hot mixture on the road within one hour of sunset.

When the edges of the pavement are not protected by a stone or concrete curb, the New Jersey highway department requires the contractor to place temporary curbs of 6 or 8-inch planks of the same thickness as the finished top course.

When it is necessary to lay half of the width of a road so as to allow traffic on the other half, the base of the first half is allowed to project about 2 feet beyond the center line of the roadway. The top course in such cases ends only a few inches beyond the center line, for this will insure all of it resting on a firm base. After the second half of the base has been constructed, the inside edge of the top course already laid is cut back vertically or nearly so along a straight or properly curved line so as to obtain a perfect joint with the second half of this course.

After the material has been spread, it should be rolled immediately. Sometimes an initial compression is given with a 3- to 6-ton tandem roller and the final compression with a 10-ton macadam roller, but the usual practice is to use a 7- to 10-ton roller giving 200 to 300 pounds per linear inch of roll. The wheels may be oiled to prevent the binder from sticking to them. This rolling is continued until the roller leaves no marks in passing. Any places which can not be reached by the roller are rammed with a hot iron tamp.

The road is often given a seal coat at the rate of ⅓ to ¾ gallon of binder per square yard, which is at once covered with pea stone or grit. The binder is often the same material used in the bituminous concrete but sometimes it is a more fluid grade.

Some engineers require it to be applied with a squeegee distributor. The seal coat is rolled until it is thoroughly incorporated with the top course.

Mixed Gravel-Asphalt Roads.—The Massachusetts highway commission has built a number of roads with mixed gravel-asphalt surfaces on gravel and broken stone bases. The surfacing with a gravel base is 2½ inches thick after rolling. The following notes from its 1915 report describe the construction:

> A road, 18 feet in width with 3-foot shoulders, was built everywhere, the curves being banked and widened to 21 feet. A gravel foundation was put in wherever the bottom was bad, and about 4 inches of local crushed stone was spread and well rolled.
>
> On this was spread, as evenly as possible, about 3 inches of a bituminous mixture made of gravel that had been run through the crusher and sand or stone dust, mixed with a heavy asphaltic product. The gravel and sand and the asphalt were thoroughly heated and were mixed in a hot mixer, and then carted onto the road and spread. The surface was rolled down to about 2 inches in thickness when the mixture was sufficiently cool not to crawl under the roller.
>
> Great care is necessary to insure a uniform product, uniformly heated, mixed and spread, and that sufficient asphalt is used and no more than sufficient to bind the mixture properly. The quantity of asphalt has to vary somewhat, according to the amount of voids in the mineral aggregate. The variation is usually from 18 to 22 gallons of the hot asphalt to the cubic yard of gravel. When the mixture is right it has about the consistency of brown sugar and compacts under the roller, though when it is first spread and rolled it sometimes has a few hair cracks which the traffic soon irons out. The asphaltic product used in this work has a penetration of from 80 to 120 with a Dow penetrometer.

Sand and Oil Roads.—In 1905 the Massachusetts highway commission surfaced a road at Eastham by distributing hot asphaltic oil over the sand which is practically the only material in the vicinity, applying 1½ gallons to the square yard in two applications. The results were so encouraging that more sand-oil roads have been built and the experience thus gained has shown what are the requirements for success. They are now built by both the penetration or layer method and by the mixing method. They are considered suitable when the traffic is mostly light teams and automobiles and will not stand up if used daily by many heavily loaded teams. The average daily traffic in 1915 on one successful layer road was 20 heavy teams, 17 light teams and 253 automobiles. On a mixed road it was 6 heavy teams, 23 light teams and 505 automobiles; on another mixed road 21 heavy teams, 38 light teams and 197 automobiles.

It is desirable for success to use a hard, strong, sharp and well-graded sand, such as is abundant on Cape Cod, where this type of construction has been developed. Many sands are too fine, too uniform in size, too rounded or not strong enough. Fair results have been obtained with some fine sands, however.

An oil asphalt of good quality that will bind and not lubricate must be used. For the layer type, the preference in Massachusetts is for an oil with a viscosity of 150 to 200 seconds at 200°C., using a Lawrence viscosimeter or about 1038 to 1384 with 100 cc. at 100°C. in an Engler viscosimeter. From 1½ to 2 gallons per square yard are used, in two applications, with a covering of sand after application. In the mixed type, oil asphalts having a penetration of 60 to 135 by the Dow penetrometer have been tried, but that now used ordinarily has a penetration of 90 to 125. From 16 to 22 gallons per cubic yard of sand have been used; the present average is 18 gallons. The Massachusetts commission advises testing each carload of oil before using it.

In the layer type of construction, the commission spreads clay or loam over the sand subgrade to reduce the rutting of the surface by wheels and pitting by horses' hoofs when the oil cart passes over it. The oil is then spread evenly while hot with a distributing cart and immediately covered with sand. This process is then repeated.

In the mixed type of construction the sand and oil are mixed hot to form a mastic which is spread over the sandy subgrade and rolled. The subgrade is carefully shaped and hardened as in the case of the penetration type. The mastic sheet is about 4 inches thick at the center and 3 inches at the edges. The best results have been obtained by keeping the road constantly shaped with a road scraper during rolling, and a seal coat of ½ gallon of a lighter oil such as is used in layer work improves the surface and decreases maintenance charges. In the early work the sand was heated on sheets of iron, but this overheated parts of it and underheated other parts, so that now the heating is done in rotary heaters.

If the traffic in the future proves too heavy for these roads, the commission believes they can be greatly improved and strengthened at a moderate cost by using harder asphalt, greater care in grading the sand, and the addition of cement and stone dust. In this way a sheet asphalt pavement 2 inches thick can be laid on the old sand-asphalt road as a base.

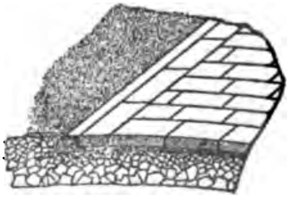
Asphalt Blocks on Country Roads

As designed and manufactured for use on country roads, the asphalt blocks are 5 inches wide, 12 inches long, and 2 inches deep, weigh about eleven pounds each, and have a specific gravity of about 2.40.

The asphalt block was developed and perfected on the theory that crushed trap rock, on account of its preëminent hardness and inherent grittiness, made the best known material for a roadway surface, the one thing needed being a cement, or binding material, to keep all of the particles permanently in place. This was accomplished by the use of an asphaltic cement to bind together the properly graded particles of crushed trap, the hot mixture being consolidated by tremendous pressure into blocks so dense and free from voids as to be practically non-absorbent. In the asphalt block, therefore, we have an asphaltic concrete, or macadam, mixed, in exact proportions, at a central plant, under conditions insuring absolute uniformity, and receiving the compression necessary to produce a dense and non-absorbent material.

Not only has a special block been produced, but a special method of construction has been worked out, designed to utilize what is left of the worn and rutted macadam road as a foundation for the blocks. This is accomplished by scarifying the surface, if necessary, filling up the deep ruts, rolling with a heavy steam roller, and laying upon the surface of the old macadam, a bed of cement mortar about 1 inch in thickness, to serve the double purpose of forming a firm unyielding bed for the blocks, and binding them securely to the macadam foundation underneath. By this method the material used in the original construction of the road is not thrown away, but used as foundation for a permanent wearing surface. Where the old macadam is too thin, or too badly worn to be safely used as a foundation, it will be necessary to lay a concrete base, but usually there is broken stone enough in the old macadam to supply what is needed for laying concrete.

A pavement may be laid of any desired width, contour, grade, or crown. It is perfectly feasible to pave one-half of the roadway, or only a narrow strip in the center, and extend the paved area at a later date as traffic necessities require, or as appropriations become available. It is not necessary to set curbstones or heading stones to border or define the paved area, since a row of stretcher blocks held firmly in place by a shoulder of mortar, as shown in the sketch, answers the purpose perfectly and leaves the entire roadway surface smooth and uniform.



A good example of this construction is on the Albany Post Road, through the villages of Hastings-on-Hudson, Dobbs Ferry, Irvington, North Tarrytown, Town of Mount Pleasant, Briarcliff and Ossining, N. Y., on the Boston Post Road in Pelham Manor and Rye, N. Y., on 9 miles of roadway from Daytona to Deland, Volusia County, Florida, and on Nassau Street, Princetown, N. J., a section of the Lincoln Highway.

BITUMINOUS SURFACE APPLICATIONS[1]

Surface applications vary widely in character, according to their purpose. In most cases such an application is essentially a maintenance measure, but in the case of the bituminous mats or wearing courses used in California, or the mats now laid on new water-bound macadam, the first cost of such work is essentially a part of the first cost of the improvement. The practice in making such surface applications of any general type varies widely in different parts of the country, more widely than the practice in any other branch of road work. Whether greater uniformity will prove desirable or the work can be done successfully by a wide variety of methods can not be definitely determined until the records of such work and of the traffic on roads are kept with more detail and uniformity than at present. The widespread interest in the subject was one of the leading characteristics of highway affairs in 1916, and was an evidence of the conditions mentioned.

Oiling Earth Roads

Surface applications on earth roads were made in California many years ago, and a method of incorporating oil and earth by a special form of roller was employed for some time. More recently well built earth roads in Iowa and Illinois have received surface applications as a maintenance measure. The experience in these states shows that while some success follows applications on roads that are not in good condition, it is very desirable to have the surface properly shaped and hard before the oil is applied. The oil binds the grains of earth together and reduces the dust, but it does not give the resistance to attrition which a hard surface affords. The treatment is therefore one which must be regarded as adapted only for roads with light traffic and light vehicles. If sand instead of earth is present, the methods of construction first used in Massachusetts and described on page 402 should be considered.

If the road has ruts and holes in the surface and is poorly drained, water will collect in puddles, soften the oiled crust at these places, and seep into the roadbed. The material under the crust will give way under heavy loads and the money spent in oiling will be largely lost, because the oiled material will become mixed with the unoiled material below and dust will be produced about as freely as on an unoiled road. Furthermore, the oiling of a mudhole often aggravates troubles due to such a defect.

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[1] **Revised by George H. Biles, second deputy State highway commissioner of Pennsylvania, and B. H. Piepmeier, maintenance engineer of the Illinois State highway department.**

The surface to receive the application must be dry, or the oil will not penetrate the pores, and it must be free from dust, for the oil forms flakes or scales with the dust and these are a worse nuisance than plain dust, being very irritating to the eyes.

Both cold and hot applications have been used successfully in Iowa, but the State Highway Commission prefers to heat the oil as it apparently gives enough better penetration to justify the additional expense. It is desirable to secure the advice of a specialist in selecting the oil. A light oil must be used and as it may have a low flash point, care should be taken to keep it at a temperature below its flash point and to prevent any of it coming into contact with a flame. The first application is made at a rate of about ½ gallon per square yard, and later applications at the rate of ¼ to ⅓ gallon. The brief experience in such work indicates that two light applications annually for two years and afterward a single application annually will be sufficient on a road adapted for such treatment and not subject to traffic requiring a more durable surface. During 1916 the Illinois State highway department issued the following advice on the work.

> The best results may be secured during the first application, by applying either a cold oil or at least a very thin product that will penetrate the surface of the road several inches and at the same time contain as many binding elements as possible so as to seal all pores in the earth, making it waterproof and at the same time adding some binding qualities that may assist the bond of the soil itself. A suitable product, as is commonly expressed, may vary from 30 to 60 per cent in asphalt. After the surface of the road has been thoroughly saturated, a hot oil or a slightly heavier product may be used.
>
> If the heavier oils are used for the first application they will not readily penetrate the surface of the road and will consequently form a mat on top. The forming of the mat before the surface of the road is more or less waterproof may be a serious fault as moisture will accumulate beneath the mat and the road will be much slower in drying out than it would had the oil not been applied. The mat surface with a soft subsoil will rut more readily, besides breaking and scaling off in large pieces, making the road surface rough and undesirable.

The Illinois authorities recommend covering the oiled surface with clean, hard sand, at the rate of a cubic yard to 100 to 150 square yards.

Broken Stone Road Surfacing

It has been found that a surface application on a new water-bound macadam road may prove unsatisfactory, although if the road is exposed to traffic for three months the desired results are obtained if the treatment is properly carried out. This is probably due to the large amount of fine, lightly-bound dust on the roadway, which is removed by the early traffic, or to the greater stability of the road as a result of its consolidation by traffic. In New York, macadam roads finished so late in the fall that they can not have three months wear before winter, are given a surface application of calcium chloride as a temporary protection against raveling during the months that must elapse before bituminous surfacing can be placed.

In making thin surface applications to an old road that is thick enough to carry the prospective traffic and has a surface in fair condition, the ruts and holes must first be patched. This is best done several days in advance of the surfacing. Each hole or rut is swept clean,[1] painted with bituminous material and filled with ¾ to 1½ inch stone and binder. The stone and binder are often mixed at a central point and carted along the road by the patching gang, for use where required. Just before the surfacing is done, the road is swept thoroughly, often with some type of revolving broom. Sometimes wire brooms are used first and then fiber brooms. The oil is applied hot or cold according to quality at the rate of about ⅙ to ⅜ gallon per square yard, as the engineer considers best, and then covered with clean screenings, granulated slag or gravel at the rate of about 60 pounds per square yard. It is advisable to secure the advice of a specialist in selecting the oil. The oil is applied by hand on small work, but usually with a distributor. If the screenings are distributed by hand they should be previously deposited in piles at convenient intervals along the roadside. They are also distributed by spreader carts. The length of time the road should be closed to traffic depends upon the weather, character of the oil, and the amount of screenings used, varying from 1 to 48 hours.

If the road oil rises through the screenings, or "bleeds," in hot weather, more screenings should be spread over those places. If the road is used mainly by automobiles, a thin covering of screenings is sometimes spread first and later a covering of sand or other fine material, to act as a filler and prevent the tires from dislodging the screenings.

The following rules for the amount of bituminous material to be used in surfacing broken stone roads were prepared by George H. Biles, second deputy highway commissioner of Pennsylvania:

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[1] It is desirable to cut the edges of a hole so as to secure vertical faces to which the new material will adhere properly; a patch with a feather edge is liable to be unsatisfactory.

> If the surface of the road is made up of pieces of ballast size stone (3-inch) from which traffic has removed all the fine material, leaving large surface voids between the stone, enough of the bituminous material must be applied so that it will flush up level to the top of the large pieces of stone and firmly bind the chips and gravel which lie in the crevices between the stone.
>
> If, on the other hand, the surface of the road is equally clean, but traffic has not removed the fine particles between these stones to the same extent, and the crevices between them are consequently smaller, then a somewhat smaller amount of bituminous material should be used, since an excess will again flow off the road.
>
> In treating a road which has recently been resurfaced, it will be found often that even after all the screenings and fine material have been swept from the top of the road leaving the large stones bare, there will still be a certain amount of dust and fine material between the stones which has not yet been compacted thoroughly by traffic and which will absorb the bituminous material like a blotter, leaving only a brown stain in these spaces. In such cases, the amount of application must be increased until this fine material is well saturated and there is enough of the bituminous material near the surface of the road to bind thoroughly the covering of chips or gravel.

The first application of a bituminous surfacing to a waterbound macadam road may be disappointing. The hoofs of horses are liable to dislodge the mat and the surface will have a spotted appearance. After several applications, however, the macadam surface will become protected everywhere.

On the New York State highways which are thick enough to carry the traffic but are too rough to be treated satisfactorily with cold oil and screenings, surfacing with two applications of hot oil is sometimes done. After the old road is patched and cleaned, it is covered with 0.4 to 0.6 gallon of oil to the square yard, over which just enough 1-inch stone is spread to cover the surface. This is rolled lightly and then covered with 0.3 to 0.4 gallon of oil per yard. This is covered with ½ inch stone in the thinnest possible layer, which is rolled as soon as the oil is cool enough to permit it.

On the Illinois highways, when a double application is made, about ¼ gallon per square yard is used on each application, and the preferred covering is torpedo sand, ⅛ to ⅜ inch in size, but clean, stone chips are also employed. The total amount of covering material with such a treatment is one cubic yard for each 125 square yards of road. When a single application is made ⅓ to ½ gallon of oil per square yard and a cubic yard of torpedo sand for every 150 square yards of road are employed.

Bituminous sandstone obtained in Kentucky has been used in parts of that state for re-surfacing old macadam. The latter is scarified, smoothed with a road machine, and enough new stone added to give the desired thickness and contour. This is rolled thoroughly and then covered with pulverized bituminous sandstone to a depth of about 1¾ inches, loose, when spread. It is desirable to allow the sun to shine on the loose material for a few hours, until it appears slightly oily, and then roll it, slowly at first and later more rapidly.

Concrete Road Surfacing

While surface applications to concrete roads have been employed in a number of states, there is no agreement as to their desirability. They have been used to the greatest extent in California, where both thin wearing surfaces and an asphaltic mixture are used. The following information concerning both types was supplied by Austin D. Fletcher, State highway engineer of California.

> The thin bituminous wearing surface is about half an inch in thickness when completed. After it has been under traffic for a few months it is found to contain a fairly uniform mixture of mineral aggregate and bituminous binder consisting of about 8 to 11 per cent of bitumen and the balance mineral aggregate of a fairly uniform grading running from dust to rock of ⅓-inch maximum diameter. It shows no tendency to flow or creep and the surface remains true and free from rolling. The concrete base, however, must be finished with a true, smooth surface to make a good riding highway as this type of surfacing is not thick enough to smooth up to any considerable extent a concrete pavement whose surface is uneven.
>
> The procedure in laying this thin wearing surface is as follows: First the surface of concrete is cleaned of dirt, dust films and any thin coat of laitance. This is best accomplished by opening the bare concrete to traffic for a month or two. The iron shod traffic and the rapidly moving rubber tires are of greatest help in breaking any weak layers of dirt or laitance and exposing the surface of the concrete proper. This "traffic cleaning" is followed by brushing with revolving street brooms and hand brooms. In some cases flushing the surface with water is a help in washing off any thin coat of clay. It is of greatest importance that the asphaltic oil bind to the solid concrete and not to any overlying weak film of dirt. The care taken in getting a clean concrete is without doubt in a large measure responsible for the success of this surfacing because of the strength of the bond between the concrete and the bituminous wearing coat. The few failures where the wearing surface has been stripped from the concrete have been nearly always easy to trace to a pavement improperly cleaned prior to the application of the road oil.
>
> After the concrete has been cleaned the asphaltic oil is applied by a pressure distributor at the rate of ¼ gallon per square yard. This oil surface is immediately covered by a layer of either crushed rock screenings or fine gravel of ⅛ to ⅓ inch. This material may contain some fines and dust but should be fairly clean.
>
> The screenings are applied by shoveling from piles placed at frequent intervals alongside the road. The shovelers can be taught to so throw the screenings that they will cover the road surface with a fairly uniform thickness. The road can now with advantage be given a light rolling but this is not necessary. Any excess screenings should be swept into piles alongside of the road to be used on the second application of road oil. This is applied on the second application at the same rate and is covered with screenings as before.

The road is now thrown open to traffic and during the first two weeks may require further screenings to take up excess oil. The traffic is of great assistance in forcing the screenings into the oil and compacting and making a homogeneous carpet on the concrete.

The oil is applied to the road at a temperature of from 250° to 300°. It contains approximately 90 per cent of 80° penetration asphalt. In California the road oil companies classify this product as a "90–80" road oil.

In building the thin bituminous wearing surface for concrete pavements two physical properties of the road oil are of greatest importance. First the oil must be of such a viscosity that when applied to the road it will readily combine with the screenings that are thrown upon its surface. A very viscous oil will form a hard surface and the screenings will lie there without being absorbed and to a large extent be thrown off the road by the passing traffic. Only a small amount will settle or be forced into the oil and the surface will not build up into a satisfactory protecting wearing coat.

The second physical property of great importance is that the road oil must be cementing or adhesive so that it will bind tightly to the concrete surface and bind together all of the fragments of stone screenings. It should be an active cement and if it is not sticky then the wearing surface will not be firm enough to resist the push and pull of the passing traffic.

The State highway routes leading from the great centers of population have required a higher type of surfacing to meet successfully the demands of heavy traffic.

After proper curing of the concrete its surface is cleaned of all dirt and dust films and given a paint binder coat composed of asphaltic cement and engine distillate of lightest gravity. The asphalt used has a penetration between 80° and 90°, the mix being one part asphalt and one to two parts distillate, the exact proportion of distillate being determined by trial. The satisfactory mixture is one that paints the concrete with a thin, uniform, glossy black film which becomes hard two hours after application.

The surfacing used has the following composition expressed in percentages:

Bitumen soluble in carbon disulphide, 7½–10

Aggregate:

PASSING	REFUSING	
200 sieve	....	8–13 per cent.
80 "	200 sieve	14–25 "
40 "	80 "	17–29 "
10 "	40 "	5–11 "
4 "	10 "	15–25 "
2 "	4 "	3–10 "
2 "	....	100 "

The asphaltic cement used has a penetration of from 70 to 90 degrees, District of Columbia standard, and passes the usual requirements for solubility, volatility and ductility. The heating of asphalt, aggregates and dust and mixing and laying follow the usual practice.

Prior to the laying of the surfacing, the testing laboratory makes grading tests of such sand, limestone dust and rock screenings as will be available for the work and selects such of these that give the desired mix. In this selection the following points are considered important:

Let a be taken as the percentage of asphaltic cement that will be used in the finished material. Then the dust passing the 200-mesh sieve should at least equal a–1. The fine sand passing the 80 mesh and retained on the 200 should be approximately $2a$. If the available sand is high on the finer sieves a may be taken as high as 9.5 per cent. If the sand is coarse, a may be as low as 8 per cent for the trial mix. The coarse aggregate passing the No. 2 sieve and retained on No. 10 should be from 28 to 35 per cent of the other mix. If these points are satisfied by the available material the weights of coarse aggregate, fine aggregate, dust and asphaltic cement can be given to the road crew for a trial batch. Under field working conditions a trial batch will show if the mix is "wet" or "dry" and by a slight change in the percentage of asphaltic cement a mixture can be made that will rake and roll properly. In this way the mineral aggregate is not changed but kept under known satisfactory grading. As the work proceeds, grading tests should be run at frequent intervals on the different mineral aggregates to insure a uniform grading in the finished pavement. Analysis of samples of the different batches should also be made to check the uniformity of the mix.

The surface after thorough rolling should have a specific gravity in excess of 2.20 if the sands and crushed rock screenings are of average specific gravities. A sample of the finished pavement taken each day and tested for specific gravity will indicate if there has been insufficient compression, either due to method of rolling or to the surface being too cold when rolled.

BRICK ROADS[1]

Brick pavements have been used on the streets of American cities for many years and the United States Bureau of the Census reports that in 1909 they formed nearly 24 per cent of the entire mileage of paved streets in 158 cities. Some of the early brick pavements gave satisfactory service for many years, but others did not. The unsatisfactory early experience was due in part to the use of unsuitable materials, in part to the improper reconstruction of pavements cut to permit laying pipes, and in part to the defective methods of construction employed, just as was the experience with other types of block pavements. It is not possible to build lasting block pavements unless the blocks are prevented from settling, which results in holes in the surface, or from tilting over on their bottom side, called "turtling," which results in a rounding of the upper edges of the blocks, called "cobbling." These defects led to better methods of construction, so that when bricks came into use on country highways success was assured if municipal experience was taken as a guide. There are always communities as well as persons unwilling to profit by the experience of others, however, and consequently some brick roads have been built of poor materials and by poor methods with the inevitable unsatisfactory results. Such unfortunate experience was unnecessary then and is unnecessary today; it was largely due to ignorance of the requirements for good work, carelessness, lack of proper supervision, and a desire to cheapen the cost of such roads below the amount needed for proper construction.

Paving Bricks

Paving bricks are made from a great variety of shales and fire clays and consequently bricks of equal worth vary considerably in appearance. Shale contains iron which makes shale bricks red when burned under normal oxidizing conditions and brown or nearly black when burned under reducing conditions. Fire clays have less iron than shales, the iron being present in a combined state, and bricks made from them are buff-colored, unless reducing conditions during burning darken them. The shales and fire clays are often unsuited for making paving bricks as they occur, and then material from one stratum in a pit must be mixed with that from another stratum or that from one pit with that from another, and sometimes with sand or surface clay.

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[1] Revised by William W. Marr, chief state highway engineer of Illinois; A. H. Hinkle, deputy highway commissioner of Ohio; P. M. Tebbs, engineer of construction of the Pennsylvania State Highway Department; Will P. Blair, secretary of the National Association of Paving Brick Manufacturers; and W. C. Perkins, chief engineer, R. T. Stull, ceramic engineer, and F. A. Churchill, of the Dunn Wire-Cut Lug Brick Company.

The raw materials are crushed and ground dry in large revolving pans under heavy rolls, called "mullers." This material is screened to remove pieces of too large size, and is then conveyed to a pug mill, in which the materials are mixed somewhat as concrete is mixed in a continuous concrete mixer. Here enough water is added to convert the material into a thick mud, which is beaten by the revolving blades into a condition of uniform consistency and composition. This mud is fed continuously into a brick machine, where it is forced by an auger through a die, whence it emerges as a fairly hard bar of rectangular section, which is cut mechanically into bricks. This bar of hard clay may be approximately 4 by 4½ inches in section, in which case it is cut about every 9 inches, forming "end-cut" bricks, or it may be approximately 9 by 4½ inches in section and cut every 4 inches, forming "side-cut" bricks. These bricks are sometimes submitted to a reshaping process before drying, in which case they are called "re-pressed" bricks, and sometimes they are dried as they are finished by the brick machine, in which case they are called "wire-cut" bricks. For drying, the bricks are placed on cars which are run very slowly through a long, tunnel-like heater, into which hot dry air is admitted continuously. After remaining on the cars in the tunnel about twenty-four hours their weight is reduced from 15 to 20 per cent. The bricks are then ready for burning, one of the most important steps in the manufacturing process. The bricks are stacked in kilns in such a way that the heated air circulates freely around them, and great care must be taken in the regulation of the temperature throughout the entire burning process, from the time the kiln is first warmed until it is cool enough to permit the withdrawal of the bricks.

In laying paving bricks a space is left between successive rows for the material which forms the joints, and as it is very desirable for these joints to be of a uniform width, one side of a paving brick has either two or four lugs, which are small projections from the surface of the bricks.[1] These projections serve to keep the adjacent faces the proper distance apart when the bricks are forced into contact during the paving operations. These projections extend ⅛ to ¼ inch from the side or face. In one class of side-cut bricks the cutting is done by wires which are moved across the bar of clay so as to produce the lugs needed on one side of the brick. These are called "wire-cut lug" bricks. In another type of side-cut bricks, 2½, 3 and 4 inches deep, the ribs are moulded on one of the sides as it comes through the die. A wire-cut side is placed on top in laying such bricks, which are called "vertical fiber" bricks in some parts of the country. Other types of projections are made by devices attached to the brick machine. In the case of repressed bricks, the projections from one or both sides are made in the press.

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[1] There are some bricks which do not have lugs but have raised letters or four projections, one near each corner, on one face. Raised letters are not permitted on bricks for Ohio State roads.

There is no universal standard size for bricks but the tendency seems to be toward 3½ inches width, 4 inches depth and 8½ inches length, with a permissible variation of ⅛ inch either way in the width and depth and ½ inch either way in length. The depth is occasionally reduced as much as an inch for roads having light traffic, when the monolithic and cement-sand cushion types of construction, explained later, are used.

"Hillside" bricks are made for use on grades of 5 per cent or more. They have one or more grooves cut the full length of the bricks, along their edges, in the case of bricks to be laid in the usual manner, or two grooves cut transversely in the case of bricks to be laid parallel with the curb. These grooves are about ⅜ inch deep and are intended to prevent slipping of horses or automobiles. Bricks with beveled edges are used for grades, notably on the carriage ramps of the Pennsylvania Terminal in New York, where the travel is very heavy, and quite generally on grades exceeding 5 per cent. throughout Ohio.

Tests of Bricks

The color of the interior of bricks from the same plant gives an indication of their quality, for generally the color is darker in the bricks burned with the higher temperatures. The color of the exterior of the bricks is a less reliable indication of quality, and even interior color is of little or no value in judging the bricks from different plants. The other features of bricks which can be determined by visual inspection are explained in the following description of the bricks which may be rejected under the standard specifications of the American Society for Testing Materials:

All bricks which are broken in two or chipped in such a manner that neither wearing surface remains substantially intact, or that the lower or bearing surface is reduced in area by more than one-fifth.[1]

All bricks which are cracked in such a degree as to produce defects such as are defined in (the previous paragraph) either from shocks received in shipment and handling, or from defective conditions of manufacture, especially in drying, burning or cooling, unless such cracks are plainly superficial and not such as to perceptibly weaken the resistance of the brick to its condition of use.

All bricks which are so off-size, or so misshapen, bent, twisted or kiln-marked, that they will not form a proper surface as defined by the paving specifications, or align with other bricks without making joints other than those permitted in the paving specifications.

All bricks which are obviously soft[2] and too poorly vitrified to endure street wear.

Formerly a number of different laboratory tests of the properties of paving bricks were required by specifications, but today reliance is placed mainly on the rattler test to determine their quality. Its name is derived from the use of a foundry rattler, employed in cleaning iron castings, in making the first tests of this kind on bricks. The rattler used today is constructed specially for the purpose. It is an iron and steel barrel of the cross-section of a 14-sided polygon, about 20 inches long and 28 inches in diameter, inside dimensions, with a shaft projecting from each end. This barrel is mounted in a frame with the shafts horizontal and can be revolved by power.

Ten dry bricks are weighed and placed within the rattler, together with an abrasive charge consisting of 10 cast-iron spheres weighing from 7 to 7½ pounds each and a sufficient number of cast-iron spheres from 1¾ to 1⅞ inches in diameter and weighing from 0.75 to 0.95 pound each, to make a total charge of 300 pounds. The rattler is then revolved 1800 times at the rate of 29½ revolutions per minute. In this way the bricks are subjected to innumerable blows which are considered to imitate the conditions of service more nearly than any other test yet devised. When the test is finished, the bricks are taken out, all pieces of them weighing less than 1 pound are discarded, and the remainder are weighed. The loss in weight during the test, expressed as a percentage of the original weight, is the form in which the results are stated.

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[1] Mr. Tebbs makes this comment: "The area of a standard brick is about 30 square inches and I consider about one-fifth or 6 square inches a very large allowance. I think that a reduction of not more than one-tenth of the area should be permitted." This comment is not approved by Mr. Blair on the grounds that experience has shown no ill effects from the rule of the Society, and to limit the reduction of area to 10 per cent. would increase materially the cost of the bricks.

[2] Mr. Tebbs advises adding the words, "not uniformly vitrified, badly laminated." The phrasing of the standard specifications was debated at great length before adoption, and uniform vitrification was not adopted as a requirement because no brick is uniformly vitrified, strictly speaking. The words "badly laminated" are sometimes used, but objection has been raised to them as not conveying to the inspector the meaning of the engineer, which is to reject bricks having laminations that are separate one from the other, sometimes called "open" laminations.

The percentage of permissible loss in the rattler test is fixed at different amounts in order to meet the conditions imposed by differences in travel and the experience of different localities with bricks of various grades. The American Society for Testing Materials gives the following scales of maximum permissible osses for different classes of travel:

CHARACTER OF TRAVEL	MAXIMUM PERMISSIBLE LOSS	
	Average	Single brick
Heavy	22	24
Medium	24	26
Light	26	28

The New York and Pennsylvania State highway departments' specifications call for the medium-travel grade and Ohio and Illinois for the heavy-travel grade. In Illinois the wire-cut lug bricks are given 1 per cent higher permissible loss than the repressed bricks, which must conform to the tabulated requirements. In that State there is a minimum permissible loss specified, 17 per cent for wire-cut and 16 per cent for repressed bricks. The average permissible maximum loss may reach 25 per cent for wire-cut lug bricks if no individual brick loses more than 28 or less than 20 per cent, and may reach 27 per cent if the range of loss of every individual brick is between 29 and 23 per cent. With repressed bricks, the average loss may reach 24 per cent, with a range of 27 to 19 per cent for every individual brick, and 26 per cent with a range of 28 to 22 per cent. These requirements put a premium on uniformity in the bricks, which many engineers regard as of importance in preventing unequal wear of the surface of a brick road. They hold that where soft and hard bricks are laid together indiscriminately, some of the bricks are worn away more rapidly than where a pavement is laid with bricks of a more uniform quality.

In New York and Ohio 30 bricks form a lot for sampling. These represent the hard, medium and light-burned bricks delivered on the job, and each grade is tested separately. During testing there is a large percentage of failures in the abrasion test, partially caused by the selection of light and hard-burned brick. The laboratory results obtained on such bricks serve as a guide in throwing out or culling part of the bricks on the job.

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Some years ago the crushing strength and specific gravity of paving bricks were considered properties which should be specified, but experience has shown that it is unnecessary to do so. The specific gravity of fire-clay bricks averages between 2.1 and 2.25 and that of shale bricks between 2.2 and 2.4. The crushing strength of good paving bricks ranges from 10,000 to 20,000 pounds per square inch, when the test load is applied over the entire top surface of the specimens, and may be higher if only a part of the surface is loaded. This is from five to ten times the probable maximum load on a pavement.

The capacity of a brick to absorb water was formerly considered an important indication of its porosity, and low porosity was held to be essential for strength and good sanitary properties, which were then considered as particular advantages of brick pavements. With the improvements that have been made in the rattler test and the increased knowledge of the slight influence of a wide range in porosity upon the sanitary value of such pavements, the absorption test has lost much of its former favor among roadbuilders. It affords useful information in comparing bricks made under identical conditions and for other research work, and it is still required by a few State highway departments. In Ohio, the bricks taken from a rattler after testing in that apparatus must not absorb more than 3½ per cent of their weight of water during immersion for forty-eight hours. In Pennsylvania, the absorption of thoroughly dried bricks immersed in water for twenty-four hours must not exceed 3½ per cent.

Another test, formerly used extensively, probably because the apparatus for making it was available in many schools and easily obtained, is the transverse or cross-breaking test. It is now little used outside of New York and New Jersey. In the former State the test required by the highway department is to place the sample brick on edge on two parallel supports 6 inches apart and load it at the center until it breaks. If the distance in inches between the supports is represented by L, the load in pounds which produces rupture by W, and the width and depth in inches of the brick by b and d respectively, the modulus of rupture will be $3WL/2bd^2$, which must not be less than 2000 pounds in bricks for New York state work.

Curbs

Curbs are required along the sides and ends of brick pavements laid on a sand cushion or laid on natural soil and having sand-filled joints, in order to hold the bricks at those places and also, with some types of base, to hold the material of the base in place. Planks have been used, but their short life compared with that of the pavement makes them undesirable, for nobody can foretell whether they will be renewed as they wear out. In some places stone slabs can be obtained for the purpose at prices which enable them to be used economically. Vitrified curbs are sometimes used, but require more careful bedding than stone curbs, because their shorter length and lighter weight render them more subject to displacement. Concrete is most generally used for curbs. In country highway work the top of the curb is usually flush with the surface of the pavement. If a concrete base is used, the curb is usually an integral part of it, and is generally from 6 to 8 inches wide on top. If a concrete base is not used, the depth of the curb must be governed mainly by the character of the subgrade, the frost hazard and the character of the shoulders. In any case it is desirable to have the top 2 inches of the concrete curb not leaner than a 1:2:3 mixture, finished with a wooden float, and the outer surface should be spaded. This spading is done by placing a spade in the form against the outer plank and rocking it back and forth so as to force the coarse aggregate of the fresh concrete away from the face.

Where the bricks are bedded on mortar or green concrete, most engineers believe that curbs are not needed.[1] If they are omitted special care must be given to providing firm shoulders along the marginal bricks.

The Base

A brick pavement requires an absolutely firm unyielding support. An old macadam road thoroughly underdrained and secure against settlement or upheaval ,is considered a satisfactory support by some engineers. But it is rarely possible to find such a road, for usually the drainage is defective, the cross-section has too much crown, or the grades are wrong. It is then necessary to disturb the hard crust of the road and this is very likely to reduce materially its value as a foundation. In some parts of Florida, where frost is not to be feared, if the sand which prevails is held in place by curbs or planks and thoroughly rolled while damp, it makes a hard, unyielding support not subject to disturbance if good drainage is assured. On the other hand, the black soil of the prairie States, which absorbs water freely and parts with it slowly, is an unstable material and a strong concrete foundation must be provided for brick roads built over it, so that any differences in the supporting capacity of the subgrade, from one season to another or between adjoining places in the road, are equalized by the concrete slab and do not cause waves in the brick surface.

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[1] Mr. Marr states: "Experience in Illinois demonstrates beyond question that curbs are not needed under such conditions. We have had several instances where the edges of the bricks were exposed at intersections to a grinding action of wheels striking them at acute angles, and there seems to be absolutely no danger of the bricks being loosened at the edges under any conditions obtaining in ordinary service."

The methods of constructing the road bed and preparing the subgrade are explained in the chapter on earth roads. It is necessary to have a uniformly firm subgrade, and if there are heavy cuts and fills the grading must be done carefully. It is desirable to allow the subgrade to go through one winter before putting down the pavement, although this is rarely practicable under the usual working conditions. The drainage is particularly important, on account of the difficulty of improving it, if defective, after the pavement is laid.

If the subgrade is firm and well drained, a 6 to 8-inch base of good gravel, broken stone, vitrified clay[1] or slag, thoroughly consolidated by rolling, may prove sufficient for moderate traffic. Such a base should be built in two courses with all the care given to the best macadam construction. In some cases, second quality paving bricks have been used for a base. The subgrade is covered with enough sand to give a depth of 2 inches after rolling with a hand roller. The No. 2 bricks are laid flat on this cushion, parallel with the curb, and the joints are filled with fine sand.

The best base for general use is concrete. A few years ago there was a general opinion that it should be 6 inches thick, but 4-inch bases on well-built subgrades are giving satisfaction where frost action is not serious, and a thickness of only 3 inches or less is under consideration by some engineers. If a secure subgrade is provided, the best thickness is in part determined by the cost of the concrete. A 1: 3½ :6 mixture with ordinary materials, laid to form a 5-inch base, may be less expensive than a 1: 2½: 5 mixture of better materials laid to form a 4-inch base. If gravel is used as the aggregate, it is generally economical to screen it and then recombine it, if good concrete is desired. If good concrete is not desired, it will be better to leave out the cement entirely and use the money thus saved in putting down a good base of the macadam type.[1] The thinner the base, the better the concrete should be. A 4-inch base of poorly graded, dirty aggregate and a pinch of cement is an invitation to early failure. One common defect is insufficient mixing. This should be done in a batch mixer which should be run between 15 and 20 revolutions per minute, and after all the materials are in the mixer, the process should be continued until the mixer has made at least 15 revolutions. The surface of the concrete should be struck off by means of a transverse templet, drawn along the side forms, and be kept well wet for at least three[2] days. No traffic should be permitted on the base for at least seven days after it is laid. On the Illinois state highways, if there are deviations exceeding $\frac{1}{4}$ inch from the desired shape of the surface, they must be repaired if a sand-cement cushion, described later, is to be employed.

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[1] Mr. Hinkle advises eliminating gravel and vitrified clay as materials for a base for this reason: "While fair foundations may be made from these materials, it so frequently happens that poor foundations result from the use of these materials that I think it well to omit referring to them here and hence not encourage their use any more than necessary." Mr. Blair believes that the long experience with gravel foundations in places like South Bend, Ind., warrants their use.

The Cushion or Bedding of the Bricks

One of the causes which contributed to limit the serviceability of some early brick pavements was the imperfect way in which the bricks were supported on the base. The latter was covered with loose sand of inferior quality for its purpose, smoothed off roughly without being consolidated, and the bricks laid on it and driven to a bearing with a paver's tamper. The joints were then filled with sand and the roadway thrown open to travel. The surface was not smooth at the outset, traffic on it soon forced some bricks down more than others, and water percolating in cold weather through the joints into the sand cushion alternately froze and thawed, throwing the bricks into irregular positions. Under such conditions the edges of the bricks became chipped, and finally many of the bricks became broken and dislodged, leaving holes in the roadway. The lesson of this experience was so clear that for a number of years the importance of bedding the brick securely has been generally recognized. Today there are three methods of doing this, termed the sand cushion, sand-cement or dry mortar bed and monolithic or green concrete bed types. The purpose of each is to support the bricks securely at the proper elevation to give the pavement a smooth surface.

Sand-Cushion Type.—A sand cushion is primarily intended to smooth out the inequalities in the top of the base, which were formerly greater than good practice now permits, to provide for the slight variations in the depth of the bricks. Experience shows that the sand must be free from large stones, which prevent satisfactory consolidation of the cushion, and some engineers hold that it must also be free from loam, clay and materials of a greasy nature when wet.[1] Granulated slag is sometimes used instead of natural sand and is believed by some engineers to be superior to ordinary sand. Dry sand must be used, according to some engineers, on the ground that wet sand shrinks in drying and cannot be relied upon to support the bricks at the desired elevation. Other engineers believe that somewhat damp sand is more easily handled and gives as good results. The thickness of this bed in the case of city streets has usually been 2 inches of late, but where a concrete base is used for a country highway and is finished so that no part deviates more than ¼ inch from the true surface, a thickness of 1½ inches is enough. On narrow roads where the concrete base is easily finished to the exact cross-section of the road, 1 inch is probably enough.[2]

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[1] Mr. Tebbs advises the use of concrete exclusively as a base for brick pavements. Mr. Blair holds that experience at Cleveland, Terre Haute and other places shows that under proper conditions a base of other material will prove satisfactory.

[2] Mr. Hinkle advocates at least five days.

The dry sand is cast over the base to a slightly greater depth than the proposed thickness of the cushion. The extra depth is usually about ½ inch where a 2-inch cushion is desired. A plank templet, which is often provided with a steel edge, is then drawn over it to smooth it down to the prescribed cross-section. If the roadway is less than about 25 feet wide, this templet is supported at the ends by the curbs. If the roadway is wider than 25 feet, the templet is long enough to reach from one curb to a longitudinal plank support at the center of the road. The sand is consolidated and brought down to grade by rolling it by hand, using a roller weighing 300 to 400 pounds. After rolling the surface is tested with the templet, the high spots reduced and the low places filled, and the rolling repeated. This process is repeated until a uniform surface at the desired elevation is obtained. The extra elevation of the templet in the first stage of the work is obtained by laying strips of wood of the requisite thickness on top of the curbs or other supports of the templet.

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[1] Mr. Tebbs makes the following comments: "Pennsylvania specifications allow 15 per cent of loam and I advocate the use of a sand containing loam, because it helps to bind it, thereby avoiding the shifting about which often occurs with clean dry sand. It has been proved that dry sand occupies less space than wet sand. Dry sand cannot always be obtained without considerable expense, and I therefore think it advisable to use reasonably dry sand without requiring that it be dried, and as thin a cushion as it is practicable to use. The cushion should be 1 inch or less. This decrease in the depth of the cushion minimizes the shrinkage due to the drying of sand which was moist when placed."

[2] Mr. Marr states: "It has been well demonstrated that the thinner the sand cushion between the rigid base and the brick wearing surface, the better, and its only function is to assure a smooth surface on the pavement. The use of the plain sand cushion is growing less every year and seems to have its greatest advantage in street paving where numerous subsequent openings may be expected and it is necessary to use a soft filler."

If a road carries only light vehicles, a well consolidated sand cushion is a satisfactory support for the bricks. Heavy vehicles, whether drawn by horses or self-propelled, are believed to jar the road although definite tests with a seismograph or a similar instrument are needed to determine the correctness of this opinion. It is certain, however, that if the roadway contains a railway track the whole structure will be jarred by the cars traveling along it. The sand cushion is not considered by many engineers to be a satisfactory support for bricks likely to be jarred, on account of the possibility that the repeated minute vibrations in it may cause parts of it to shift their position. This apprehension has led to the use of the sand-cement bed.

Sand-cement Cushion Type.—The cushion consists of a dry mixture of one part of cement with three to five parts of mortar sand. These materials must be thoroughly mixed dry. If the cushion is to be 1 inch thick, as in Pennsylvania state work, the mixture contains less cement than if it is to be ¾ inch thick as in the Illinois State work. The loose material is given about ½ inch greater depth than the desired thickness of the finished bed. The mortar is spread and shaped like a sand cushion. In Illinois, where the sand-cement bed has been used extensively, the shaping of the bed for the brick is considered of prime importance and the State highway department requires the contractor to employ skilled men for this part of the work.

There is a difference of opinion as to the best method of moistening the sand-cement bed to convert it into mortar. Some engineers hold that the bricks should be laid on the dry bed and rolled, and then the pavement should be sprinkled sufficiently to allow water to pass down the joints into the bed. This wetting down should be done as soon as the bricks have been rolled. The Pennsylvania highway department requires the mortar bed to be sprinkled lightly just before the bricks are laid. In any case, the mortar bed should not be laid so far in advance that any of it will remain exposed over night, and if any of it becomes wet and the cement sets it must be replaced by dry material.

*Monolithic Type.**—The monolithic or green concrete bed is not actually a cushion, for the bricks are laid on the fresh concrete base as soon as it has been finished. In this type of work steel side forms for the base are generally specified and curbs are omitted. The steel forms are considered necessary as supports for the heavy steel templet which is used.

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* A monolithic brick pavement was laid about 1904 in Terre Haute, Ind., on the recommendation of Street Commissioner Varrelman of St. Louis. It was on a railroad teaming yard and a private street to the warehouse of Hullmann & Company. This is probably one of the earliest uses of the type in this country.

The concrete is placed in successive batches for the entire width of the pavement in a continuous operation. This concrete as placed has a slightly greater depth than the finished thickness of the base, and the workmen are guided in placing it by a light wood templet which rests on the side forms when in use. When it has been brought to a smooth surface of the desired shape, it is finished with a steel templet. This consists of a 6-inch steel I-beam in front and a 6-inch steel channel at the rear, held 2 feet apart by a metal frame at each end. Each frame has two rollers 3 feet or more apart. These rollers rest on the side forms and permit the templet to be moved ahead easily and without jerks. Both beams are bent to the desired crown of the pavement. The lower flange of the I-beam is $\frac{1}{8}$ to $\frac{3}{16}$ inch lower than that of the channel. The space between the two beams is kept filled with dry 1:3 mortar, thoroughly mixed. As the templet is moved along, the I-beam shapes the fresh concrete accurately, and the channel leaves a thin, compacted bed of mortar on its surface, so that the bricks have a support which is true to grade in every respect. Experience shows that particular care must be taken in this type of construction to use concrete which will not flow but will quake. If it flows it will not support the bricks and if it does not quake it will be deficient in strength. The bricklaying should follow closely behind the templet before the concrete takes its initial set, and the workmen are required to move with special care over the bricks just laid. Some engineers require boards to be laid for the workmen to walk and stand on.

Delivering and Laying Bricks

In case the bricks are not tested at the plant, each carload must be sampled as it is delivered and the lot should not be allowed on the road until the samples have been tested and approved. If this is not done, imperfect bricks are likely to find their way into the road, and the work of roadside inspection is made needlessly expensive and prolonged.[1]

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[1] Mr. Hinkle calls attention to the following paragraphs in the specifications of the Ohio State highway department: "If all the bricks in a shipment or in several shipments of the same make and kind of bricks appear to be uniform in quality two samples of 12 each may suffice. If in a shipment there appears to be different classes of bricks, such as bricks that appear to be more or less burned than others, a representative lot of 12 bricks is to be secured for each class of bricks, exclusive of the culls. The approximate number of each class sampled should be given on the notification card accompanying the samples. Unless otherwise ordered by the Engineer, at least one lot of samples should be taken for every

Bricks are liable to considerable injury if handled roughly, and to prevent such injury to them after their acceptance by test many engineers specify the manner in which they shall be handled. The requirements of the Illinois highway department are as follows:

> Before the fine grading is finished, the bricks shall be hauled and neatly piled without the edging line in sufficient quantities to complete the brick surface. Clamps and conveyors may be used in connection with the work but the bricks shall not be dumped from industrial cars or vehicles, nor shall they be thrown to piles or to industrial cars or to vehicles. The bricks shall not be piled in any place where they will be likely to be besplattered or covered with mud or otherwise injured. In delivering the bricks from the piles for placement in the pavement, no wheeling in barrows will be allowed on the brick surface, but they shall be carried on pallets. They shall be placed upon the pallets so that when delivered to the dropper they will lie in such order that each brick in the regular operation of placing it upon the foundation as prepared, will bring the lugs in the same direction with the best side uppermost.

The bricks are laid with the best side up and the projections for spacing all in the same direction; in highway work they are laid in rows or courses at right angles to the curb. Alternate rows commence with a half brick at the curb and the joints in a row must be at least 3 inches from those in the row last laid. When the row reaches the curb towards which it is laid it must be completed with a bat at least 3 inches long. The fractured end of a broken brick must be toward the center of the road. Brick layers generally carry three or four rows across the roadway simultaneously, as this enables them to save considerable walking. The bricks are laid from the bricks already in place, and no walking is permitted on the cushion or dry mortar bed. In order to keep the cross joints of uniform width, after about six or eight rows have been laid, a 4 x 4-inch timber 3 feet long is moved along the face of the last row and tapped lightly with a sledge.

After the bricks are laid the surface is swept clean and inspected. The soft bricks are replaced by good ones; they are detected by

100,000 bricks, care being taken to secure bricks from different parts of the cars or piles so that the samples submitted will be representative of the bricks to be used. If at any time a shipment of bricks is received in which the quality of the bricks does not appear equal to that of the samples previously submitted, additional samples should be immediately sent to the testing laboratory. A sufficient number of samples in every case should be taken to insure the use of bricks of proper quality, but it should be borne in mind that the charges for transportation are high and only a sufficient number of samples should be submitted for test, which will permit of proper control of the quality of bricks used."

Thousands of Bricks Required to Pave a Mile of Road of Different Widths with Different Numbers of Bricks per Square Yard

BRICK PER SQUARE YARD	WIDTH OF STREET						
	8	10	12	15	18	20	22
33	174.2	193.6	232.3	290.4	348.5	387.2	425.9
34	179.5	199.5	239.4	299.2	359.0	398.9	438.8
35	184.8	205.3	246.4	308.0	369.6	410.7	451.7
36	190.0	211.2	253.4	316.8	380.1	422.4	464.7
37	195.3	217.1	260.5	325.6	390.7	434.2	476.9
38	200.6	222.9	267.5	334.4	401.3	445.9	490.5
39	205.9	228.8	274.6	343.2	411.7	457.6	503.4
40	211.2	234.7	281.6	352.0	422.4	469.4	516.3
41	216.5	240.5	288.6	360.8	432.9	481.1	529.2
42	221.8	246.4	295.7	369.6	443.5	492.8	542.1
43	227.1	252.3	302.7	378.4	454.1	504.6	555.0
44	232.3	258.1	309.8	387.2	464.6	516.3	567.9
45	237.6	264.0	316.8	396.0	475.2	528.0	580.8
46	242.9	269.9	323.8	404.8	485.8	539.8	593.7

dampening the surface of the road for they absorb moisture more quickly than the others. Bricks which are badly broken, spawled or misshaped are turned over or replaced by good ones, but slight chipping of the corners is not considered serious.[1] The surface is then rolled, for which purpose a tandem self-propelled roller weighing 2½ to 4 tons is employed where a sand cushion is used and a hand roller about 2½ feet long and 2½ feet in diameter, weighing about 600 pounds, is preferred for monolithic pavements. The rolling should begin at one side of the road and proceed back and forth on lines slightly inclined toward the center of the roadway. When the center is reached the roller should be used on the other side of the road in the same way. Parts of the pavement which cannot be reached by the roller are rammed with a paver's tamper weighing about 50 pounds, the blows being struck on a 2-inch plank 10 to 12 inches wide and at least 6 feet long.

After the rolling, the pavement is again inspected and any bricks which have been broken or seriously injured are replaced. The joints are examined, and if the sand-cushion has been forced up into them more than ½ inch in the sand-cushion type, the bricks are lifted out, the cushion reshaped, and the bricks relaid. This inspection of the joints is only necessary where a sand cushion is used.

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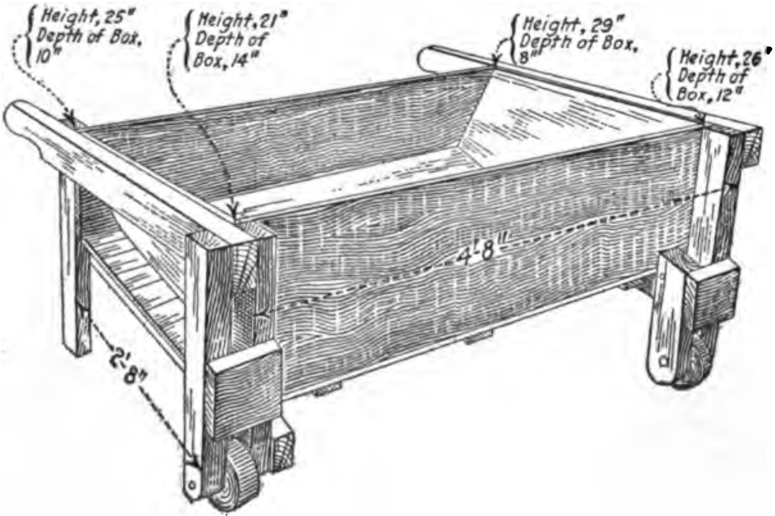
[1] Mr. Hinkle considers that it is very desirable for all defective bricks to be culled out before the bricks are laid in the pavement. This will not only save the expense of replacing the defective bricks with good ones, but will avoid disturbing the cushion. This is more important with the monolithic than with other types of pavement.

Filling Joints

Joints between the bricks are filled with sand, cement grout or bituminous material. Sand is objectionable because it gives very little support to the bricks, allows their edges to become chipped, and permits water to percolate down into the cushion. It is no longer employed except for roads for light travel, where the saving in first cost is considered more important than the probability that maintenance expenses will become high at an early date.

Grout Fillers.—The grout filler is strongly advocated by many engineers on the ground that it holds the bricks firmly and does not wear away more rapidly than the vitrified clay. This claim rests upon the assumption that good grouting is done, for poor joints of this type are chipped out by horses' shoes and thus allow the edges of the bricks to become broken. If the grouting is properly done this will not happen.[1] It is extremely im-



Box for Mixing Grout

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[1] Mr. Marr states: "The cement-grouted pavement seems to be the most satisfactory for country highways, and this has led us in our studies in Illinois to attach great importance to the perfection of the grout filler. We have been working along the line that, theoretically, the earth itself is the foundation for the pavement and is in itself wholly adequate, if it is thoroughly settled and properly drained. In other words, we hold that ordinary dry earth sustains any load which we place upon it while it is

portant, however, with cement filler that a rigid foundation be secured.

Grout for filling joints should be made of equal parts of cement and clean, sharp, sand mixed thoroughly while dry. As a general rule, all of it should pass a No. 10 sieve but not more than 30 per cent should pass a screen having 50 meshes to the inch. After the sand and cement are thoroughly mixed dry, water is added to bring the mass to a condition somewhat thinner than thin cream, so it will flow into the joints without any separation of its ingredients. The mixing is kept up continuously, either in a small batch mixer or the box shown in the accompanying illustration. The tendency on extensive work is to use a batch mixer equipped so it can be used for applying the grout. If the box is used, about 2 cubic feet of the dry mixture is made into mortar in each batch. The best grout is obtained when the water is added slowly.

The surface of the pavement to be grouted is cleaned, well wet, and then covered with enough grout to about fill the joints. The grout is taken from the mixing box in scoops and after it is poured from them it is swept into the joints, usually with coarse rattan brooms. After a 50-foot section of road has had the joints filled in this manner, and before the grout first poured begins to set, a somewhat thicker grout is made and applied on the same surface. It is brushed into the joints with squeegees having rubber edges where they rest on the pavement. This process of applying the relatively thick grout and brushing it into the joints with squeegees is continued until the joints are completely filled. It is very desirable to apply the grout, so far as possible, to the exact parts of the pavement where it is to fill the joints. If any great excess of grout is applied at one place in the pavement and swept to another place, the cement and sand are liable to become separated and defective grout will result. If the bricks have rounded edges, the squeegees should be pressed

in this condition, and that the real problem is to keep it in this condition by covering and waterproofing it with some material which will withstand the abrasive action of traffic. This, in turn, leads us to believe that if we use a thin base, such, for instance, as 2 inches of sand and cement mixed, or even 1 inch, or even, theoretically, ½ inch, the properly grouted bricks will then withstand successfully the action of any such traffic as we have at the present time.

"The mortar bed has for its prime function the insurance of a perfect grout joint, by preventing earth or other foreign matter from working up into the bottom of the joints during construction. It has a secondary value in enabling us to obtain a smoother wearing surface by facilitating the proper grading of the bed on which the bricks lie by the use of mechanical methods such as templets. We have built a 6-mile stretch of brick road 9 feet wide, on a 1-inch mortar bed base, which I believe will demonstrate the correctness of the theory we are now holding."

firmly against them on the last brushing so that no thin edges of grout will remain on the surface, for they break away very soon and are liable to pull a part of the joint filler with them.

To prevent the grout from flowing through the joints beyond the limits of the section where the filling is being done, strips of $\frac{1}{16}$ inch steel 6 inches wide and 3 feet long are inserted in the last transverse joint, to act as a dam until after the initial set of the cement.

After the surface has been inspected, it is the practice in Illinois to cover it with sand, which is kept wet for ten days, and no travel is permitted on the road for three weeks after the grout has been poured. In Ohio and Pennsylvania, the sand is kept damp for at least five and four days respectively, and travel is kept off for at least ten days. In New York travel is kept off for ten days, and the covering must be kept moist for that period. The National Association of Paving Brick Manufacturers advises keeping the covering wet for four days and travel off the road for fifteen days.

Bituminous Fillers.—Bituminous fillers vary greatly in quality, and the experience with some of the materials tried has not been satisfactory. The filler should not become soft during hot weather nor brittle during cold weather, it should adhere to the bricks, and it should not be injured by water. A 1:1 bituminous-sand mastic filler has recently been used considerably. Obviously climatic conditions should govern the selection of the material in some degree, for a filler suitable for the brick pavements of Florida might prove unsatisfactory during a New England winter.

The Ohio State requirements for asphalt fillers are as follows:

Specific gravity, 0.98 to 1.04.

Solubility in chemically pure carbon disulphide, at least 99½ per cent.

Matter soluble in 86°B. paraffin naphtha, 25 to 40 per cent.

Limits for penetration

TEMPERATURE	NEEDLE	WEIGHT	TIME	PENETRATION
°C.		*grams*		
25	No. 2	100	5 sec.	2.5 to 5 mm.
4	No. 2	200	1 min.	2 mm. or more
46	No. 2	50	5 sec.	10 mm. or less

Melting point by cube method, 80°C. to 120°C.

It shall be free from water and not foam when heated to 350°F.

The Ohio State requirements for coal tar pitch fillers are as follows:

Specific gravity at 25°C., 1.23 to 1.3.

Free carbon on extraction with carbon disulphide, 20 to 40 per cent.

Inorganic matter on ignition, 0.5 per cent.

Melting point by cube method, 57°C. to 63°C.

It shall be free from water and not foam when heated to 300°F.

These bituminous fillers are used hot and the bricks should therefore be dry when the joints are poured. If a sand-cement bed is used, the water for it must be applied through the joints, if it is added in that way, long enough before the joints are filled to permit them to become dried out.

The filler is melted in a kettle, from which it is usually drawn into funnel-shaped pourers terminating in a nozzle having an opening about ½ inch in diameter, with a valve by which the flow through it can be regulated. This is held over the joint, with the nozzle projecting into it, and carried along slowly. The joints are somewhat overfilled by the pourer, on the theory that the early travel on the pavement will force some of the surplus material into the joint and make it more dense. After the joint is poured, some engineers have it dusted over with sand, and it is customary to keep traffic off the pavement until the filler has cooled.

A mixture of tar and sand, called a "mastic filler," has been used to some extent. The hot tar and heated sand are mixed in equal volumes. A softer grade of tar is used in the mixture than that called for by the Ohio specification for a tar filler. This mastic filler is flushed into the joints by pouring it onto the pavement and spreading it with a squeegee.

It is particularly desirable to roll the bricks and fill the joints to within at least 50 feet of the bricklaying work. If rain falls and the cushion becomes saturated, it is impossible to roll the bricks to a firm condition, for the wet sand allows them to rock and the cushion is forced up into the joints. By lifting out a brick here and there, the height of the sand in the joint can be seen and the character of the rolling judged from it.

Expansion Joints

In the early days of brick street pavements, the bricks at the crown of a street occasionally rose in summer as a result of the expansion of the pavement by heat. To remedy this, joints filled with some compressible material were laid along one or both curbs, and some engineers used similar transverse expansion joints at intervals of 50 to 75 feet. The longitudinal joints have proved useful, but there is some question as to the value of the transverse joints in street pavements. The objection to transverse joints is that they are worn away rather rapidly and

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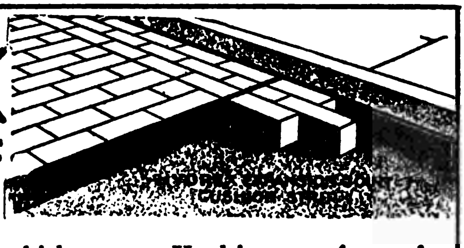

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this causes the travel to chip off the edges of the bricks separated by them. Whenever this chipping occurs to any extent, the pavement soon develops a rut or hole. Cracks in a country road, if properly filled when they first open and kept filled afterward, do not injure it appreciably, and it is generally considered that transverse joints in a brick wearing surface, to prevent transverse cracks, are more likely to cause than prevent trouble.

Expansion joints are of two types, poured and prepared. The former are made by placing a board filler of the thickness of the joint against the curb and laying the bricks against it. The Maryland rule for the thickness of the joints is as follows: On streets 30 feet or more wide, 1¼ inches next each curb; on 20 to 30-foot streets, 1 inch next each curb; on 12 to 20-foot streets, ¾ inch next each curb; on streets under 12 feet, ¾ inch next one curb. In Pennsylvania a ½-inch joint at each curb is specified. On the Illinois brick roads with a sand-cement base a ⅜-inch joint along one curb is used. The plank filler usually consists of two thin 6-inch boards of a wedge-shape cross-section, dressed on both sides. One of them is laid against the curb with the thin edge on the base, and the other is placed against it with the thick edge downward. The combined thickness of the two is equal to the thickness of the joint. Handles are attached to their upper edges, so they can be lifted out when the grout filler which has been poured has set. The filler for poured expansion joints should meet the requirements for the filler for other joints of this type. With the monolithic and sand-cement cushion types of pavement, the joints should be filled as far as the bricks are laid, each day.

Prepared fillers are now extensively used. They are strips of bituminous material or some kind of felt or fabric impregnated with bituminous material. They are placed against the curb and the bricks laid against them, thus doing away with the board fillers required with poured joints and making it unnecessary to provide heating kettles on pavements with grouted joints.

Experience on the Pennsylvania State highways has shown that a prepared filler extending the full depth of the brick sometimes permitted water to penetrate from the road surface into the cushion, where it froze and heaved the bricks. It is therefore considered advisable on that work to have the prepared filler stop from ¾ to 1 inch below the surface of the road and to fill the top of the joint with hot bituminous material.

Where a cement-sand bed is used, a ⅜ inch prepared expansion joint extending through the entire pavement is recommended by some engineers; it is placed in two strips, the first or bottom strip being placed in the concrete base, and the second strip immediately above it when the bed and bricks are laid.

Small Cubical Bricks

Shortly after small stone blocks were introduced in Europe for constructing pavements having the trade name of "Durax," the county superintendent of Monroe County, N. Y., J. Y. McClintock, employed cubes measuring 2 to 2½ inches on a side for resurfacing old macadam roads to resist motor traffic. In 1916 he stated that vitrified clay cubes had given better results than those of other materials. Those laid in 1916 were 2½ inches in each dimension, weighed about 1 pound each, and were laid 225 to the square yard. The only specification for the cubes is that they must not absorb more than 3 per cent. of their weight when immersed in water. They have been laid on a gravel base, broken slag, broken stone and concrete, and the joints are filled with any local fine material. It is considered advisable to make the base several feet wider than the roadway, so that the gravel or broken stone shoulders adjacent to the cubes shall be supported rigidly and the tendency for the border cubes to become displaced will be minimized.

Aspha-Bric

During 1915 and 1916 attention was directed to the possibilities of asphalt impregnated brick. The idea of impregnating brick with bituminous material is not new. In 1893 brick boiled in coal tar were laid in Portland, Ore., and remained in service 17 years. About 1907 nose brick boiled in asphalt were laid along the tracks of the Los Angeles Electric Railway Corporation and 2500 similar brick were laid along tracks in San Francisco about 1912. Brick boiled in bituminous material have also been laid in Nashville and Chattanooga.

The method of treating brick which came into prominence in 1915 is designed to fill completely the pores in the brick. As the porosity of different grades and makes varies considerably, the quantity of impregnating material required will range from about 6 to 15 per cent of the volume of the brick. As a result of the treatment it is claimed that the brick become impervious to moisture, the bituminous jointing material adheres more firmly to the treated than to the untreated brick, and the wearing properties, as indicated by the standard rattler test, are greatly improved. This last advantage is indicated in the accompanying tabulation of tests of untreated and treated "second" brick conducted by Robert W. Hunt & Company. Each test was made with five untreated and five treated brick, 225 pounds of small shot and 75 pounds of large shot, the rattler making 1800 revolutions at the rate of 30 revolutions per minute. The increase in wear due to

Results of tests of untreated and asphalt impregnated brick. Each sample consisted of five untreated and five treated brick

SAMPLE	1	2	3	4	5	6	7	8	9
Weight in pounds:									
Before treatment....	50.66	48.81	46.50	53.35	45.25	48.65	49.75	47.95	50.03
After treatment.....	56.75	54.01	48.97	55.77	47.49	51.33	54.60	49.94	54.53
Asphalt used........	6.09	5.20	2.47	2.42	2.24	2.68	4.85	1.99	4.50
Loss in weight, pounds:									
Untreated...........	27.02	17.39	28.81	17.19	13.93	11.88	19.57	13.63	11.78
Treated.............	8.38	8.96	6.22	10.07	6.51	6.83	7.36	6.46	6.25
Loss in weight, per cent:									
Untreated...........	53.34	35.63	61.96	32.22	30.79	24.42	39.34	28.43	23.55
Treated.............	14.77	16.59	12.70	18.06	13.71	13.31	13.48	12.94	11.46
Broken brick:									
Untreated...........	1	0	3	0	0	0	0	0	0
Treated.............	0	0	3	1	0	0	0	0	0

impregnation will, it is stated, enable manufacturers to stop their burning at a lower temperature than is now customary, thus materially reducing the number of poor brick in a kiln, and to obtain the necessary strength by impregnating the brick. It is also claimed that grades of brick unsuitable for pavements may be made into satisfactory pavers by impregnation. For example, impregnating clay building brick with 11.3 per cent of asphalt gave a product showing 9.3 per cent loss in the standard rattler test, although untreated brick showed 100 per cent loss after 500 revolutions. Shale building brick which showed 42.4 per cent loss in the rattler test before they were treated, lost only 17 per cent after treatment. Sand-lime brick which showed 100 per cent loss after 400 revolutions lost only 23 per cent after being impregnated with 10 per cent of asphalt. Impregnating clay and shale building brick with 8½ per cent of asphalt reduced the loss in the rattler test from 40.9 to 14.2 per cent. The impregnation of the brick also reduces their absorption of water to practically nothing.

The asphalt-impregnating process begins when the brick are removed from the kilns or dryers. They are loaded on small cars which are run into a cylinder. There they are heated to about 300°F., which expands them, and a vacuum is produced in the cylinder to remove all moisture from the brick and leave their pores open. The cylinder is then filled with a special grade of asphalt at a temperature of 350°F. and the cylinder put under heavy pressure until the gauges show that impregnation is complete. The asphalt is drained off and pressure again applied until the brick have cooled. During cooling they contract somewhat, causing the asphalt to become sealed in the pores.

A BRICK PAVEMENT ON A ONE-INCH CONCRETE BASE[1]

A brick pavement was laid in 1917 in Stockland township, Iroquois County, Illinois, on a one-inch concrete base. This pavement is 9 feet wide, and the contract is for about 6½ miles, of which about 3 miles has been constructed. The contract price for this work is approximately $8700 a mile, of which about $300 is for bridges and culverts and about $450 for grading. The price for the slab alone is $1.50 per square yard.

This pavement is being laid on an old gravel road for a foundation and, in order to secure the full benefit of this old material, the gradient of the new pavement varies but slightly from that of the present road. By not disturbing the old gravel, it has been possible to secure a very firm subgrade and we have no doubt but the pavement will prove very satisfactory. The concrete base is composed of 1 part cement to 2½ parts fine aggregate and 4 parts coarse aggregate. The fine aggregate consists of sand all of which passes a ¼-inch mesh. The coarse aggregate consists of material which would be retained on a ¼-inch mesh and passes a ½-inch mesh. As a matter of fact, there is very little of this material which will not pass a ⅜ inch mesh and it is the same type of gravel that is commonly used for roofing purposes.

I have no doubt but this pavement would be practically as good as if the brick had been laid directly on the old gravel road, but in a construction of this kind, it is necessary to have some sort of a concrete base in order to secure a perfectly smooth and uniform surface on which to lay the bricks.

The subgrade was thoroughly rolled and all soft places, of which there were very few, were removed and the subgrade brought up to a true plane by the addition of fresh material which was thoroughly compacted. Before concrete was placed, the subgrade was well wet; after the concrete was placed, it was struck off by means of a template and the bricks were laid directly on the green concrete.

Two brick setters were used on this job and by having a brick hammer on each side of the road, the setters not only started but finished the courses, as on a pavement of this width no bats, except one half-sized brick, are required in starting and finishing the courses. Bricks were carried on to the pavement in such a way that the good side of the bricks was always placed up and the lugs all in one direction. By requiring the brick carriers to use some care, a large amount of the culling which ordinarily takes place on a brick road was eliminated. Just as soon as the bricks were culled, the pavement was swept and the rolling started.

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[1] By Rodney L. Bell, Division Engineer, Illinois State Highway Department.

One man did nothing but keep the roller moving the entire time. It was a small hand roller about 30 inches in length and 24 inches in diameter and when filled with water weighed about 700 pounds. This weight was sufficient to secure a good surface over the entire length of the pavement. The first rolling was begun at the outer edge and the pavement was rolled parallel to the center line of the pavement. After the entire surface had been covered in this way, the pavement was cross-rolled in opposite directions, the roller making an angle of about 45 degrees with the center line of the pavement.

In order to allow plenty of time to secure a thorough job of rolling, the grouting machine was kept about 100 feet behind the brick layer. The grout mixture consisted of one part cement and 1 part of sand mixed in a machine designed for this purpose. It was the intention to practically fill the joints at the first application so that after the grout had had a chance to settle, it would leave from ½ to ¾ inch to be filled with subsequent applications.

The second application of the grout was mixed slightly thicker than the first, and was wheeled back over the pavement from the mixing machine rather than bother with moving the machine back over the pavement a second time. This application was worked into the joints by use of a squeegee and on the final going over, the squeegees were pulled at an angle of about 45 degrees with the joints in order to secure a better surface and to keep the grout from being dragged out from between the brick.

After the grout had set sufficiently, the pavement was covered with 1 inch of loose dirt, which was kept wet for one week. The pavement was opened to traffic after it had been down three weeks.

This work is being paid for by a bond issue which has been voted by Stockland township, Iroquois County, and is under the general supervision of Benj. Jordan, county superintendent of highways of Iroquois County.

PART III

Miscellaneous Information and Tables

HIGHWAY BONDS[1]

The mathematical theory of interest as applied to bond calculations is explained in a section of Bulletin 136 of the United States Department of Agriculture which was reprinted by permission in the 1916 GOOD ROADS YEAR BOOK, with tables of much value to those making a detailed examination of the subject. For the usual purposes of highway officials, however, the much simpler tables which are printed herewith are not only sufficient in scope but also more easily used.

The bonds used almost universally until a few years ago were of the sinking-fund type. Parties issuing them have to provide annually during the term of the bonds the stipulated interest and, theoretically, set aside a sum at interest which will amount at the end of the term to the principal of the bonds. This annual sum set aside at interest is called the sinking fund, and the amount which must be raised for such a fund depends upon the interest it bears. This interest is usually quite low in comparison with the interest paid on the bonds.

Unfortunately the financial methods of public officials do not always remain above criticism and it often happens that the annual payment into the sinking fund is forgotten or neglected.[2] Sometimes the money accumulated in the sinking fund is diverted from its purpose. Such departures from sound finance result in a lack of money to pay off the bonds when they become due, as agreed, and it then becomes necessary to issue a new series of bonds to carry this indebtedness. This is a serious matter when the improvements for which the bonds were issued have become of no further use, as in the possible case of a worn-out road surface, or obsolescent, as in the possible case of an overloaded bridge, when the taxpayers who contribute for the second bond issue are obliged to pay for something for which they receive little or no benefit. This is not equitable, and so some states fix the term of bonds which may be issued to pay for certain classes of improvements. In New Jersey, for example, the term of bonds for gravel roads is limited to five years, waterbound or bituminous macadam ten years, bituminous concrete fifteen years, 6-inch concrete twenty years, block pavements twenty years, sheet asphalt on a concrete base twenty years, and stone, concrete and iron bridges thirty years. The useful life of the improvement is what must be considered, and this is determined in some cases by obsolescence rather than depreciation, notably in the case of bridges. The attractiveness of bonds for road work would be enhanced in many cases if an equivalent of the following statute, in force in Mississippi, were generally adopted:

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[1] Revised by B. K. Coghlan, associate professor of highway engineering, Agricultural and Mechanical College of Texas.

[2] Baker, Watts & Co., bankers, of Baltimore, make the following comment: "We view it as a very serious matter to neglect the sinking fund, regardless of the character of the improvement for which the bonds are issued. We think that public officials cannot be too forcibly impressed with the absolute necessity of managing public funds strictly in accordance with the laws and ordinances authorising bond issues, and any neglect or diversion of public sinking funds should be summarily dealt with."

> The public highway or highways so surveyed and adopted by such commissioners shall be constructed and maintained out of the proceeds of such bonds; proceeds of such bonds to be used alone in their construction; and the board of supervisors shall levy an annual tax, on the recommendation of such commissioners, on all the taxable property in such district or districts of not exceeding 1 mill on the dollar, which shall be used to supplement the general fund of the county in maintaining said road or roads and the culverts, bridges and levees thereon.

The importance of maintenance of roads is so great that statutes authorizing bond issues for construction should require, as part of the stipulations under which the bonds are issued, an adequate financial provision for the upkeep of the roads during the term of the bonds. This insures a full statement of the financial obligations of the bond issue upon the taxpayers before they vote on the issue.

The investment of the sinking fund affords an indication of the financial ability of a community. In some sections of the country, the investment is intrusted to special boards of sinking fund commissioners, and appointment to such a board is regarded as a high honor, so that the positions are filled by men of the highest business standing. In such cases the community not only feels confident of its financial stability but its bond issues are sought so eagerly that it is not necessary to pay high rates of interest. In a few places, sinking funds have been neglected and the financial standing of the community suffers in consequence.

A second type of bond is known as the annuity bond. An annuity is a fixed sum paid at regular intervals of time for either a definite term or for the life of the beneficiary of the annuity. An annuity bond draws interest at an agreed rate, but at the close of each retirement period stated in the bond, the payment to the bondholders includes both the interest that has accrued during the period since the last payment and enough of the principal to make the full payment a definite, uniform amount at the close of each retirement period. The annual payment at the end of the first retirement period is mainly for interest and that at the end of the last period is mainly for retiring the last of the outstanding principal. The advantage of the plan is that it retires some principal annually and thus saves the taxpayer the expense of paying interest on the whole of a bond issue during its term. This makes annuity bonds less expensive than sinking fund bonds to the county issuing them.

The annuity bond issue possesses the advantage of requiring the same amount to be raised each year, during its term. The annual payments must be adjusted, however, so that the amount of principal retired will be some multiple of $100, $500 or $1000, or whatever sum is the face value of one bond. Consequently the actual payment on annuity issues at the end of a retirement period is not the uniform theoretical amount given in bond tables but an amount varying slightly from it, sometimes more and sometimes less.[1]

The serial bond issue is a type which has found favor with both borrowers and lenders. The farmer finds it desirable because it retires each year a part of the principal, and is thus more economical than a sinking fund bond issue. The purchasers of the bonds like them because there is a strong public sentiment in favor of serial bonds, which gives them standing as a good type of investment security. It is the least expensive method of borrowing money by issuing bonds, as an examination of the accompanying tables will show.

One defect of serial bonds for certain classes of public improvements is that the heaviest payments for interest and the retirement of principal must be made in the early years of the term of the bonds, before the work for which they pay has yielded any returns. Consequently what are known as deferred serial bonds are now used to meet such conditions as often arise in road districts. With such a type of bond, no principal is retired until a certain period, usually five years, has elapsed. During this period interest is paid but nothing more. Thereafter the principal is retired by uniform amounts and the interest charges are met just as in the case of straight serial bonds having a term shorter by five years, or whatever is the deferred period. In this way a road district need not pay anything but interest until the improvements have begun to yield a return and it need not pay so much for the use of money as when it issues sinking fund bonds.

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[1] The following comment on this type of bond has been received from John S. Harris, of the banking house of Sidney Spitzer and Company, Toledo: "We would not suggest your recommending the installment (annuity) bonds, as they are very hard to figure and hard to dispose of. It is necessary to figure each year when you collect your coupons the amount of principal and the amount of interest. A serial bond answers the same purpose and is much more attractive to the investing public. Road bonds should not be issued in any other way than as serial bonds, as every one knows that issuing long-time road bonds is wrong."

The question which taxpayers generally put to public officials regarding a bond issue is what increase such an issue will make in the annual taxes. A series of examples will show how the accompanying tables can be used to answer such questions.

What is the tax rate for a $300,000 issue of 5 per cent, 40-year bonds, retired by a sinking fund drawing 3 per cent, when the tax valuation of the road district is $9,300,000?

The table of the annual cost of sinking fund bonds shows that the annual cost of a $1 bond of this class is 6.326 cents. The annual cost of a $300,000 issue will be $18,978. The additional tax per $100 valuation in the district will be $18,978 ÷ 93,000 = 20.407 cents. Any taxpayer can find out what his additional tax will be by multiplying 20.407 cents by the number of hundreds of dollars worth of property for which he is assessed. If his property is assessed at $2000, for example, his additional tax for roads will be $4.08.

How much money would be saved by issuing annuity rather than sinking fund bonds in this case?

The annual cost of a 1-dollar 4-per cent, 40-year annuity bond is shown by the table to be 5.828 cents, so the annual cost of a $300,000 issue will be $17,484. The additional tax per $100 valuation will be 18.8 cents, or 1.607 cents less than under the sinking fund system. The man whose property is assessed at $2000 would save 32 cents, and the district as a whole would save $1494.51, which would go a long ways toward paying for the engineering expenses of the road improvement.

What is the least expensive type of a $300,000 issue of 5 per cent, 40-year bonds to the above district?

The four accompanying tables show that the straight serial bond is the least expensive type, for the average annual cost of a 1-dollar bond of this type is 5.062 cents. This is equivalent to $15,186 for a $300,000 issue. The additional tax per $100 valuation will be 16.329 cents, 4.978 cents less than under the sinking fund type, which will save 81 cents to the man having property assessed at $2000. The saving to the district will be $3792 as compared with a sinking fund issue and $2298 as compared with an annuity issue.

The drawback of a straight serial bond can be seen from the figures of the payment needed at the end of the first and the fortieth years, 7.5 and 2.625 cents respectively on a 1-dollar bond. Road improvements do not yield any benefits until completed, and by deferring payment on the principal for five years, the additional cost to the community will average only $939 a year. The maximum annual amount will be somewhat higher than in a straight 40-year serial issue, because the principal must be retired in 35 years instead of 40 years, but this disadvantage may not outweigh the desirability of deferring the repayment of the principal.

The management of a bond issue requires attention to all the requirements of the laws governing such matters and a knowledge of the conditions which affect the value of bonds. Every step which the law requires to be taken in connection with such bonds must not only be taken properly but recorded fully and clearly. As soon as the voters authorize the issue, a statement of the fact should be drawn up, showing also the area, population and assessed valuation of the district, the value of its agricultural and industrial products, its material resources and the extent of their development, the banking and transportation facilities serving it, the existing indebtedness of the district, the condition and number of the schools, and all other information which will indicate the resources and character of the community that has decided to borrow the money. This information should be sent to banking houses and insurance companies making a specialty of purchasing public bonds and, if the issue is a large one, it should be advertised in financial journals. There should be ample time between the publication of these notices and the sale of the bonds for purchasers to make a full investigation of them.

[1] Private sales of bonds for public works should be discouraged all sales of bonds should be publicly advertised, and bidders should be invited to submit sealed bids on or before a certain date. The bonds should be sold to the highest responsible bidder who complies with all of the terms and conditions of the sale. The city or county should reserve the right to reject any or all of the bids, as a protection against any effort to pool bids and purchase the bonds at a price considerably less than their value.

Some cities and counties engage competent attorneys, familiar with the preparation of the legal papers pertaining to bond issues, to examine the records prior to the sale and to prepare all necessary forms. The city or county assumes the expense for all such work and furnishes the successful bidder with the approving opinion of the counsel thus engaged and with the executed bonds. Some cities and counties go even further by providing uniform proposal blanks for the bonds and refusing to accept bids not made on such blank. The advantage of these provisions is that the seller knows he is offering a legally and validly issued bond, the buyer has the same assurance, and the value of the issue is certainly enhanced thereby. The seller is undoubtedly reimbursed for the expense incurred in such preparatory work by the price he receives for the bonds.

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[1] This and the next paragraph were prepared by Baker, Watts & Company.

Annual cost of a 1-dollar sinking-fund bond for different terms, interest rates and rates of interest on sinking fund

INTEREST ON SINKING FUND	TERM	RATE OF INTEREST ON BONDS, PER CENT							
		4	4.25	4.5	4.75	5	5.25	5.5	6
per cent	*years*	*cents*	*cents*	*cents*	*cents*	*cents*	*cents*	*cents*	*cents*
2	5	23.216	23.466	23.716	23.966	24.216	24.466	24.716	25.216
	10	13.133	13.383	13.633	13.883	14.133	14.383	14.633	15.133
	15	9.783	10.033	10.283	10.533	10.783	11.033	11.283	11.783
	20	8.116	8.366	8.616	8.866	9.116	9.366	9.616	10.116
	25	7.122	7.372	7.622	7.872	8.122	8.372	8.622	9.122
	30	6.465	6.715	6.965	7.215	7.465	7.715	7.965	8.465
	35	6.000	6.250	6.500	6.750	7.000	7.250	7.500	8.000
	40	5.656	5.906	6.156	6.406	6.656	6.906	7.156	7.656
	45	5.391	5.641	5.891	6.141	6.391	6.641	6.891	7.391
	50	5.182	5.432	5.682	5.932	6.182	6.432	6.682	7.182
2.5	5	23.023	23.273	23.523	23.773	24.023	24.273	24.523	25.023
	10	12.926	13.176	13.426	13.676	13.926	14.176	14.426	14.926
	15	9.577	9.827	10.077	10.327	10.577	10.827	11.077	11.577
	20	7.915	8.165	8.415	8.665	8.915	9.165	9.415	9.915
	25	6.928	7.178	7.428	7.678	7.928	8.178	8.428	8.928
	30	6.278	6.528	6.778	7.028	7.278	7.528	7.778	8.278
	35	5.821	6.071	6.321	6.571	6.821	7.071	7.321	7.821
	40	5.484	5.734	5.984	6.234	6.484	6.734	6.984	7.484
	45	5.227	5.477	5.727	5.977	6.227	6.477	6.727	7.227
	50	5.026	5.276	5.526	5.776	6.026	6.276	6.526	7.026
3	5	28.835	23.085	23.335	23.585	23.835	24.085	24.335	24.835
	10	12.723	12.973	13.223	13.473	13.723	13.973	14.223	14.723
	15	9.377	9.627	9.877	10.127	10.377	10.627	10.877	11.377
	20	7.722	7.972	8.222	8.472	8.722	8.972	9.222	9.722
	25	6.743	6.993	7.243	7.493	7.743	7.993	8.243	8.743
	30	6.102	6.352	6.602	6.852	7.102	7.352	7.602	8.102
	35	5.654	5.904	6.154	6.404	6.654	6.904	7.154	7.654
	40	5.326	5.576	5.826	6.076	6.326	6.576	6.826	7.326
	45	5.079	5.329	5.579	5.829	6.079	6.329	6.579	7.079
	50	4.887	5.137	5.387	5.637	5.887	6.137	6.387	6.887
3.5	5	22.648	22.898	23.148	23.398	23.648	23.898	24.148	24.648
	10	12.524	12.774	13.024	13.274	13.524	13.774	14.024	14.524
	15	9.183	9.433	9.683	9.933	10.183	10.433	10.683	11.183
	20	7.536	7.786	8.036	8.286	8.536	8.786	9.036	9.536
	25	6.567	6.817	7.067	7.317	7.567	7.817	8.067	8.567
	30	5.937	6.187	6.437	6.687	6.937	7.187	7.437	7.937
	35	5.500	5.750	6.000	6.250	6.500	6.750	7.000	7.500
	40	5.183	5.433	5.683	5.933	6.183	6.433	6.683	7.183
	45	4.945	5.195	5.445	5.695	5.945	6.195	6.445	6.945
	50	4.763	5.013	5.263	5.513	5.763	6.013	6.263	6.763
4	5	22.463	22.713	22.963	23.213	23.463	23.713	23.963	24.463
	10	12.329	12.579	12.829	13.079	13.329	13.579	13.829	14.329
	15	8.994	9.244	9.494	9.744	9.994	10.244	10.494	10.994
	20	7.358	7.608	7.858	8.108	8.358	8.608	8.858	9.358
	25	6.401	6.651	6.901	7.151	7.401	7.651	7.901	8.401
	30	5.783	6.033	6.283	6.533	6.783	7.033	7.283	7.783
	35	5.358	5.608	5.858	6.108	6.358	6.608	6.858	7.358
	40	5.052	5.302	5.552	5.802	6.052	6.302	6.552	7.052
	45	4.826	5.076	5.326	5.576	5.826	6.076	6.326	6.826
	50	4.655	4.905	5.155	5.405	5.655	5.905	6.155	6.655

Annual cost of a 1-dollar sinking-fund bond for different terms, interest rates and rates of interest on sinking fund—Continued

INTEREST ON SINKING FUND	TERM	RATE OF INTEREST ON BONDS, PER CENT							
		4	4.25	4.5	4.75	5	5.25	5.5	6
per cent	*years*	*cents*	*cents*	*cents*	*cents*	*cents*	*cents*	*cents*	*cents*
4.5	5	22.279	22.529	22.779	23.029	23.279	23.529	23.779	24.279
	10	12.138	12.388	12.638	12.888	13.138	13.388	13.638	14.138
	15	8.811	9.061	9.311	9.561	9.811	10.061	10.311	10.811
	20	7.188	7.438	7.688	7.938	8.188	8.438	8.688	9.188
	25	6.244	6.494	6.744	6.994	7.244	7.494	7.744	8.244
	30	5.639	5.889	6.139	6.389	6.639	6.889	7.139	7.639
	35	5.227	5.477	5.727	5.977	6.227	6.477	6.727	7.227
	40	4.934	5.184	5.434	5.684	5.934	6.184	6.434	6.934
	45	4.720	4.970	5.220	5.470	5.720	5.970	6.220	6.720
	50	4.560	4.810	5.060	5.310	5.560	5.810	6.060	6.560

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Annual cost of a 1-dollar annuity bond for different terms and rates of interest

TERM	RATE OF INTEREST ON BONDS, PER CENT							
	4	4.25	4.5	4.75	5	5.25	5.5	6
years	*cents*	*cents*	*cents*	*cents*	*cents*	*cents*	*cents*	*cents*
5	22.462	22.621	22.779	22.938	23.097	23.257	23.418	23.740
10	12.329	12.483	12.638	12.794	12.950	13.108	13.267	13.587
15	8.994	9.152	9.311	9.472	9.634	9.798	9.963	10.296
20	7.358	7.522	7.688	7.855	8.024	8.195	8.368	8.718
25	6.401	6.571	6.744	6.919	7.095	7.274	7.455	7.823
30	5.783	5.960	6.139	6.321	6.505	6.692	6.880	7.265
35	5.358	5.541	5.727	5.916	6.107	6.301	6.497	6.897
40	5.052	5.242	5.434	5.630	5.828	6.029	6.232	6.646
45	4.826	5.022	5.220	5.422	5.626	5.833	6.043	6.470
50	4.655	4.856	5.060	5.267	5.478	5.691	5.906	6.344

Variations in annual cost of a 1-dollar serial bond for different terms and rates of interest, the principal being retired by the same amount at the end of each year

TERM	PAYMENT	RATE OF INTEREST, PER CENT							
		4	4.25	4.5	4.75	5	5.25	5.5	6
years	*date*	*cents*	*cents*	*cents*	*cents*	*cents*	*cents*	*cents*	*cents*
5	First year.....	24.000	24.250	24.500	24.725	25.000	25.250	25.500	26.000
	Last year.....	20.800	20.850	20.900	20.950	21.000	21.050	21.100	21.200
	Average.......	22.400	22.550	22.700	22.850	23.000	23.150	23.300	23.600
10	First year.....	14.000	14.250	14.500	14.750	15.000	15.250	15.500	16.000
	Last year.....	10.400	10.425	10.450	10.475	10.500	10.525	10.550	10.600
	Average.......	12.200	12.337	12.475	12.613	12.750	12.888	13.025	13.300
15	First year.....	10.667	10.917	11.167	11.417	11.667	11.917	12.167	12.667
	Last year.....	6.933	6.950	6.967	6.984	7.000	7.017	7.034	7.067
	Average.......	8.800	8.933	9.067	9.200	9.333	9.467	9.600	9.867
20	First year.....	9.000	9.250	9.500	9.750	10.000	10.250	10.500	11.000
	Last year.....	5.200	5.213	5.225	5.238	5.250	5.263	5.275	5.287
	Average.......	7.100	7.231	7.362	7.494	7.625	7.756	7.887	8.144
25	First year.....	8.000	8.250	8.500	8.750	9.000	9.250	9.500	10.000
	Last year.....	4.160	4.170	4.180	4.190	4.200	4.210	4.220	4.240
	Average.......	6.080	6.210	6.340	6.470	6.600	6.730	6.810	7.120
30	First year.....	7.333	7.583	7.833	8.083	8.333	8.583	8.833	9.333
	Last year.....	3.467	3.475	3.483	3.491	3.500	3.509	3.517	3.535
	Average.......	5.400	5.530	5.658	5.787	5.916	6.046	6.175	6.434
35	First year.....	6.857	7.107	7.357	7.607	7.857	8.107	8.357	8.857
	Last year.....	2.971	2.978	2.985	2.993	3.000	3.007	3.014	3.028
	Average.......	4.914	5.047	5.171	5.300	5.428	5.557	5.685	5.942
40	First year.....	6.500	6.750	7.000	7.250	7.500	7.750	8.000	8.500
	Last year.....	2.600	2.606	2.613	2.619	2.625	2.632	2.640	2.654
	Average.......	4.550	4.678	4.806	4.934	5.062	5.191	5.320	5.577
45	First year.....	6.222	6.472	6.722	6.972	7.222	7.472	7.722	8.222
	Last year.....	6.311	3.316	2.322	2.328	2.333	2.339	2.344	2.355
	Average.......	4.267	4.394	4.522	4.650	4.777	4.905	5.033	5.288
50	First year.....	6.000	6.250	6.500	6.750	8.000	7.250	7.500	8.000
	Last year.....	2.080	2.085	2.090	2.095	2.100	2.105	2.110	2.120
	Average.......	4.040	4.167	4.295	4.427	4.550	4.677	4.805	5.060

Variations in annual cost of a 1-dollar deferred serial bond for different terms and rates of interest, the principal being retired by the same amount at the end of each year beginning with the end of the sixth year

TERM	PAYMENT	RATE OF INTEREST, PER CENT							
		4	4.25	4.5	4.75	5	5.25	5.5	6
years	*date*	*cents*	*cents*	*cents*	*cents*	*cents*	*cents*	*cents*	*cents*
10	1–5 years......	4.000	4.250	4.500	4.750	5.000	5.250	5.500	6.000
	Sixth year....	24.000	24.250	24.500	24.725	25.000	25.250	25.500	26.000
	Last year.....	20.800	20.850	20.900	20.950	21.000	21.050	21.100	21.200
	Average.......	13.200	13.400	13.600	13.800	14.000	14.275	14.400	14.800
15	1–5 years......	4.000	4.250	4.500	4.750	5.000	5.250	5.500	6.000
	Sixth year....	14.000	14.250	14.500	14.750	15.000	15.250	15.500	16.000
	Last year.....	10.400	10.425	10.450	10.475	10.500	10.525	10.550	10.600
	Average.......	9.467	9.641	9.817	9.992	10.166	10.342	10.516	10.867
20	1–5 years......	4.000	4.250	4.500	4.750	5.000	5.250	5.500	6.000
	Sixth year....	10.667	10.917	11.167	11.417	11.667	11.917	12.167	12.667
	Last year.....	6.933	6.950	6.967	6.984	7.000	7.017	7.034	7.067
	Average.......	7.600	7.762	7.925	8.088	8.250	8.413	8.575	8.900
25	1–5 years......	4.000	4.250	4.500	4.750	5.000	5.250	5.500	6.000
	Sixth year....	9.000	9.250	9.500	9.750	10.000	10.250	10.500	11.000
	Last year.....	5.200	5.213	5.225	5.238	5.250	5.263	5.275	5.287
	Average.......	6.480	6.635	6.790	6.945	7.100	7.255	7.410	7.715
30	1–5 years......	4.000	4.250	4.500	4.750	5.000	5.250	5.500	6.000
	Sixth year....	8.000	8.250	8.500	8.750	9.000	9.250	9.500	10.000
	Last year.....	4.160	4.170	4.180	4.190	4.200	4.210	4.220	4.240
	Average.......	5.733	5.883	6.033	6.183	6.333	6.483	6.592	5.933
35	1–5 years......	4.000	4.250	4.500	4.750	5.000	5.250	5.500	6.000
	Sixth year....	7.333	7.583	7.833	8.083	8.333	8.583	8.833	9.333
	Last year.....	3.467	3.475	3.483	3.491	3.500	3.509	3.517	3.535
	Average.......	5.200	5.347	5.492	5.639	5.785	5.932	6.079	6.372
40	1–5 years......	4.000	4.250	4.500	4.750	5.000	5.250	5.500	6.000
	Sixth year....	6.857	7.107	7.357	7.607	7.857	8.107	8.357	8.857
	Last year.....	2.971	2.978	2.985	2.993	3.000	3.007	3.014	3.028
	Average.......	4.800	4.947	5.087	5.231	5.375	5.519	5.662	5.199
45	1–5 years......	4.000	4.250	4.500	4.750	5.000	5.250	5.500	6.000
	Sixth year....	6.500	6.750	7.000	7.250	7.500	7.750	8.000	8.500
	Last year.....	2.600	2.606	2.613	2.619	2.625	2.632	2.640	2.654
	Average.......	4.489	4.630	4.772	4.914	5.055	5.198	5.340	5.624
50	1–5 years......	4.000	4.250	4.500	4.750	5.000	5.250	5.500	6.000
	Sixth year....	6.222	6.472	6.722	6.972	7.222	7.472	7.722	8.222
	Last year.....	2.311	2.316	2.322	2.328	2.333	2.339	2.344	2.355
	Average.......	4.240	4.380	4.720	4.385	4.799	4.415	4.530	4.759

RESISTANCE OF ROADS TO TRACTION

The resistance to traction of a small number of pavements of different types, in different conditions was investigated in 1915 by the electrical engineering department of the Massachusetts Institute of Technology. A half-ton electric delivery wagon was used, and each test was made by driving the wagon over the test pavement in one direction and then in the other, so that the effect of the wind, if any, would be neutralized by averaging the results of the runs in both directions. The tests are described in a paper presented to the American Institute of Electrical Engineers in June, 1916, by Profs. A. E. Kennelly and O. R. Schurig. The results were summarized in the accompanying illustration.

Curve 1 is nearly flat, and the authors state that if the effect of air resistance was eliminated from the total resistance to traction, the resistance of a good level asphalt pavement would be about 17 pounds per ton at all speeds. Such a pavement in poor condition had a resistance of about 23 pounds per ton when the wagon ran at 12 miles per hour and 25 pounds at 15 miles. There were no tests of wood block pavements in poor condition; curve 2 gives the results for a good pavement.

Curve 3 is for a good brick pavement; the effect of slight wear of bricks was to increase the tractive resistance to 25 pounds per ton at 12 miles and about 30 pounds at 15 miles.

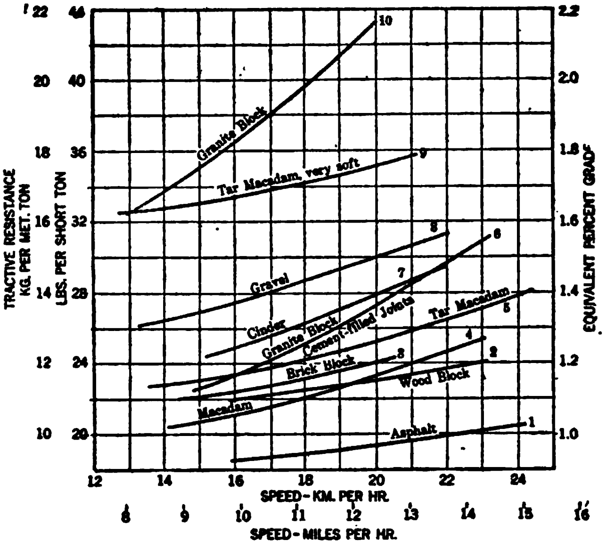
Curve 4 is for a dry, hard water-bound macadam road in fair condition. A similar road in a dusty condition showed an increase of 3 pounds in the resistance to traction at all speeds. A poor, damp road in poor condition offered a resistance of 33 pounds at 10 miles and 39 pounds at 13 miles. Oiling a good water-bound macadam road increased its resistance to traction about 5 pounds, this increase gradually growing larger as the speed increased.

Curve 5 is for bituminous macadam in good condition. The curve for another road in good condition began with a resistance of a little under 26 pounds per ton at 9 miles an hour and increased to 32 pounds at 14 miles. An old road of this type in poorly patched condition offered a resistance of about 29 pounds at 8 miles and 37 pounds at 13 miles. A good road which was recently treated and still soft had a resistance of 33 pounds at 8 miles and nearly 36 pounds at 13 miles, as shown in Curve 9. A very poor, soft road with many holes had a resistance of 41 pounds at 7 miles and 54 pounds at 12 miles, showing what a rapid increase to resistance follows an attempt to go at even moderate speed over such a road.

The authors make the following comments of the tests:

There are three principal elements which determine the tractive-resistance curve for different speeds and a given vehicle, within the range of conditions covered by the tests.

The first element is a constant resistance, the magnitude of which depends on the lack of resilience of the road surface and the tires, that is to say, on the energy losses due to displacement of tire material and road-surface material. This constant element would be encountered upon a smooth, level road of the particular type considered, in the absence of impact, air and wind resistance.



Curves Showing Resistance to Traction at Different Speeds.

The second element is an increasing resistance with increasing speed due to impact losses. This resistance results from lack of smoothness of the road surface and varies approximately as the second power of the velocity at impact.

The third element is an increasing resistance with increased speed. It is due to the air pressure against the front of the vehicle and varies approximately as the second power of the speed.

The first element is called the displacement resistance, the second the impact resistance and the third the air resistance. The displacement resistance is very marked in Curve 10, for a granite-block pavement with sand joints. The displacement resistance varies, not only with the type and surface quality of the road, but also with the type, dimensions and quality of the tires on the wheels. The same tires were used in the experiments by Kennelly and Schurig. The air resistance of a given vehicle at any given speed is the same for all classes of pavement. The impact resistance of a road depends not only on the type and character of the road surface and the sizes of its irregularities, but also on the type, dimensions and quality of the tires on the wheels, the weight of the truck and the quality of its springs.

Increasing the gross weight of the vehicle by 12 per cent, through load, was found to have no effect on tractive resistance within the observed speed limits for smooth roads in good condition; but on rough roads, a distinct increase in tractive resistance with this extra weight was observed.

PATENTS RELATING TO ROADS, ROAD MACHINERY AND ROAD MATERIALS ISSUED BY THE UNITED STATES PATENT OFFICE IN 1916

Compiled by United States Office of Public Roads and Rural Engineering

1,160,171. Process for the simultaneous production of soluble alkali hydroxids and cement-making material. A. W. Heyman.

1,160,172. Process for the simultaneous production of soluble alkali compounds and cement-making materials. A. W. Heyman.

1,160,554. Cast iron culvert pipe. R. C. White.

1,160,794. Traction vehicle. J. A. Vansickler.

1,161,016. Road building machine. E. J. Akins.

1,161,205. Rotary spray nozzle for road treating machines. S. E. Finley.

1,161,956. Machine for manufacturing ribbed and hillside paving blocks. J. B. Nicholson.

1,162,029. Machine for spreading road surfacing material. G. Burns.

1,162,822. Draft attachment for automobiles, (for pulling the machine out of chuck holes and the like). K. C. Thomson.

1,163,241. Reinforced concrete post. J. P. Kimble.

1,163,605. Art of converting molten slag into a highly porous mass. C. H. Schol, Allendorf, Germany.

1,164,208. Tractor. J. Persley.

1,164,307. Tractor. Nils Nilson and Leonard Nilson.

1,164,309. Traction machine. N. and L. Nilson.

1,164,310. Traction machine. N. and L. Nilson.

1,164,334. Ground for cement coated walls. E. D. Coddington.

1,165,137. Double walled strainer for culverts, drainage casings, etc., and connecting means therefor. A. Smith.

1,165,331. Road sanding apparatus (for distributing sand on the surface of roadways, and for projecting the sand with force upon oiled roadways). G. H. Gray.

1,165,425. Culvert. T. F. Lundergan.

1,165,708. Tractor. J. W. Porter.

1,165,753. Preservative treatment of timber. W. D. Clark.

1,165,304. Manhole cover fastening, E. S. Quigley, assignor to Quigley Furnace & Foundry Co.

1,165,930. Motor driven tractor. E. Adler.

1,166,036. Steering gear for road machines (see patent 1,130,471). F. E. Arndt, assignor to Galion Iron Works & Mfg. Co., Galion, O.

1,166,051. Roadway (or pavement having metallic base on which surfacing material is placed). E. F. Kammer.

1,166,188. Road making machine. T. S. Culbreath.

1,166,197. Road scraper. P. C. Elsey.

1,166,246. Tractor (with reference particularly to the mountings for the driving wheels). C. A. Olson.

1,166,251. Ditching and grading machine. W. T. Phipps.
1,166,664. Curbing block. L. Dargento.
1,167,494. Highway track. F. J. Hardecker.
1,167,495. Highway track. F. J. Hardecker.
1,167,585. Concrete curb armor. C. A. Miller and C. K. Doak.
1,167,615. Reinforcing in concrete. H. C. Barnes.
1,168,585. Combined road grader and drag. J. W. Woolery.
1,168,723. Road grader. E. B. Harris.
1,169,619. Road machine. A. Conkel.
1,169,810. Corner bar (for protecting concrete). J. F. Havemeyer.
1,169,834. Armor plate setting device (for the expansion joints of a concrete roadway). T. H. Kane, assignor to Trussed Concrete Steel Co., Detroit, Mich.
1,170,269. Road grading machine. E. A. Hyde.
1,166,509. Process of recovering solid by-products from wood pulp liquor. A. B. Ayerst and C. N. Waite.
1,166,745. Apparatus for utilising heat from hot slag. W. H. Daily.
1,168,570. Tar drag. S. B. Sheldon.
1,168,768. Process for manufacturing compressed asphalt blocks. C. B. Upham.
1,168,784. Drainage excavator. M. G. Bunnell.
1,169,153. Tractor. C. Hibacsko.
1,169,234. Drainage excavator. M. G. Bunnell.
1,169,569. Machine for loading earth and like materials. A. C. E. Roberts.
1,169,689. Drainage casing for culverts, drain tiling, wells, etc. A. Smith.
1,170,031. Traction engine. M. J. Williams (heavy-duty type).
1,170,578. Plow (snow plow). H. T. Toy.
1,170,592. Road grading machine and ditches. W. R. Williams.
1,171,084. Road grader. E. E. Barrett.
1,171,236. Road-making composition. E. A. Paterson.
1,171,316. Collapsible core for concrete culverts. A. E. Camblin.
1,171,441. Rail filler (in connection with paving), H. C. Innes, assignor to The Philip Carey Mfg. Co., Lockland, O.
1,171,491. Post mold (to mold concrete posts in place). D. L. Woods.
1,171,771. Excavating machine (for ditching). P. A. Christensen.
1,172,012. Road sanding machine. J. D. Curtis, assignor to Richardson Mfg. Co., Worcester, Mass.
1,172,075. Gas traction engine. R. C. Townsend.
1,172,225. Artificial stone composition. Pierre Robert.
1,172,305. Snow plow. P. G. Paige.
1,172,495. Excavator (power shovel). W. N. Springer, assignor to Avery Co., Peoria, Ill.
1,172,559. Mixing machine (for paving and building purposes). N. M. Rosendahl.
1,172,579. Excavator. M. G. Bunnell.
1,173,014. Road working machine. N. S. Monroe.
1,173,015. Road machine. N. S. Monroe.
1,173,016. Road working machine. N. S., A. J., and G. W. Monroe.
1,173,035. Digging and ditch cleaning device. E. N. Rich. (Irrigation ditches and the like).
1,173,313. Tractor (direct drive). J. P. Schmit.
1,173,505. Street crossing. A. Hale.
1,173,539. Road machine. T. S. Rogers.
1,173,681. Road grading and ditching machine. J. R. Pile.
1,174,260. Pavement. T. F. McGilvray.
1,174,351. Snow plow. S. C. Repsholdt.

1,174,483. Road drag. H. Erickson.
1,174,803. Power tamping machine. C. E. Bathrick.
1,174,905. Spraying machine (for trees, etc.). A. C. Seeger.
1,174,986. Ditching machine. E. Jeschke.
1,175,096. Tractor (improved propelling and steering mechanism). R. V. Wallace.
1,175,174. Rotary road grader. A. M. Peterson.
1,175,263. Road machine. J. H. C. Hird.
1,175,384. Center draft fair lead (for stump pullers and other draft lines). B. E. Shinoe.
1,175,422. Method of treating sulfite waste liquor. W. K. Freeman, assignor to Hydrolose Process Corp., New York.
1,175,423. Method of treating waste sulfite liquor and products produced thereby. W. K. Freeman, assignor to Hydrolose Process Corp.
1,175,426. Cement composition (composed of sulfite waste of wood pulp mills, etc., for flooring, posts, etc., exposed to earthy ingredients). W. K. Freeman, assignor to Hydrolose Process Corp.
1,175,430. Road grader. A. Fry.
1,175,451. Tractor (to admit drive wheels being set at different elevations). E. E. Howell.
1,175,553. Square turn tractor. N. Newell.
1,175,678. Road sweeping machine. W. Barnett, and J. Florendine.
1,176,006. Process of manufacturing asphalt. R. Wallbaum of Germany.
1,176,416. Concrete mixer. E. Wiet, assignor to Parrott & Co., San Francisco, Calif.
1,176,611. Reversible concrete gutter and drain block. J. T. Smith.
1,177,267. Process of disintergrating fibrous material. R. P. Perry, assignor to Barrett Mfg. Co.
1,177,799. Sprinkling attachment for automobiles (for sprinkling roads). W. Patterson.
1,174,160. Kominuter or lining plate for ball mills. A. V. Jensen.
1,174,271. Tile laying machine. E. C. Perry.
1,174,713. Wheeled scraper. O. P. Hallock.
1,175,926. Breast cutting open ditch excavator. M. G. Bunnell.
1,176,419. Ditching machine. W. H. Alleman.
1,176,591. Drag. N. S. Monroe.
1,176,994. Mechanically formed roadway. T. C. Spelling.
1,177,156. Waterproofing and weatherproofing composition. Hermann von der Heide, of Unna-Konigsborn, Germany.
1,177,781. Conveyer control for ditching machines. L. A. Krupp, assignor to Buckeye Traction Ditcher Co., Findlay, O.
1,178,523. Ditching machine, A. B. Latham, and P. F. Cook, Jr.
1,178,700. Pavement joint. R. D. Baker.
1,178,756. Roadway. R. P. Scott.
1,178,979. Process of binding roads and road beds and composition therefor. J. P. Walsh.
1,179,000. Road drag. L. Gast.
1,179,323. Power flusher. H. D. Johnson, Jr., assignor to Studebaker Corp., South Bend, Ind.
1,179,487. Automobile track. L. Williams.
1,179,608. Road drag. G. Carroll.
1,180,237. Apparatus for the distillation and fractionation of petroleum and other liquids. H. L. Burleson and P. W. Prutzman.
1,182,272. Road drag. A. W. Hodge.
1,182,779. Ditching machine. C. Lee.
1,175,992. Route indicator. W. E. Reilly.
1,180,557. Wheeled scraper. J. E. Adams.

1,181,976. Fireproof lubricating oil. R. R. Graf.

1,182,590. Grading machine. C. M. Anderson.

1,182,601. Process and apparatus for making asphaltum. M. J. Trumble, assignor to Simplex Refining Co., of California.

1,182,872. Reinforced concrete culvert. J. H. Darrow.

1,183,070. Paving block construction. S. Josten.

1,183,238. Chain drag. A. Robertson.

1,183,506. Composite pavement and process of laying it. E. C. Wallace.

1,183,507. Process for producing wearing surfaces for streets and roads. E. C. Wallace.

1,183,675. Rotary transmission dynamometer with recording apparatus. M. Rockstroh.

1,183,850. Wheeled scraper. M. O. Bright.

1,183,954. Road Grader. W. Clark.

1,184,274. Street flushing apparatus. J. M. Thompson.

1,184,522. Spring wheel. J. Ehrhard. (for automobiles.)

1,184,634. Culvert. C. J. Duerrwachter.

1,184,803. Apparatus for preparing paving materials. L. B. West.

1,184,913. Ditching machine. H. L. Augur.

1,184,945. Wood paving block. W. J. Gilbert, assignor to Compressed Wood Preserving Co., Cincinnati, O.

1,185,072. Arched crossover trackway. A. N. Durbin.

1,185,090. Road building machine. H. N. Hall.

1,185,291. Corner guard for concrete curbing and the like. A. E. Davis.

1,185,358. Road grading machine. W. R. Williams, assignor to Owensboro Ditcher and Grader Co., Owensboro, Ky.

1,185,359. Road grading and ditching machine. W. R. Williams, assignor to Owensboro Ditcher and Grader Co., Owensboro, Ky.

1,185,488. Guard structure. N. B. Ellery.

1,185,774. Cementitious material. E. L. Conwell, assignor to Aluminate Patents Co., Philadelphia, Pa.

1,185,863. Road drag. R. H. Anderson.

1,186,108. Arch. D. B. Luten.

1,186,109. Bridge. D. B. Luten.

1,186,110. Bridge. D. B. Luten.

1,186,376. Sectional concrete culvert. L. Chapman.

1,186,549. Pavement plow. C. H. Clark.

1,186,725. Road grader. A. J. and E. E. Akers.

1,187,000. Viscoscometer. C. O. Lorenz.

1,187,001. Ditching machine. H. W. Lutz.

1,187,228. Road planer and smoother or scraper. R. A. Jones.

1,187,509. Sheet metal culvert. J. H. Dean.

1,187,959. Heating and mixing plant (heating mineral aggregate with the bituminous cement for pavements). H. W. Ash, assignor to Warren Bros. Co., Charleston, W. Va.

1,188,081. Process of treating bituminous compositions. L. Kirschbraun.

1,188,281. Snow plow. N. P. Larsen and J. W. Coonfield.

1,188,715. Road roller. F. H. Beach.

1,188,928. Scarifier. H. M. Gooding.

1,189,123. Motor snow plow. J. A. Keller.

1,189,700. Machine and process for mixing road material. W. L. Kerlin, assignor to Willite Road Const. Co.

1,189,700. Machine and process for mixing road material. W. L. Kerlin, assignor to Willite Road Const. Co.

1,190,019. Device for heating and applying coating material (for applying asphalt). E. E. Seale.

1,190,085. Viscosity testing apparatus. H. F. Bauer.

1,190,257. Road roller. J. H. Henderson.
1,190,257. Road roller. J. H. Henderson.
1,190,365. Road machine. F. E. Arndt, assignor to Galion Iron Works & Mfg. Co., Galion, O.
1,190,615. Plastic composition (for use in pavements, paving blocks, etc.) H. P. Willis, assignor to Willite Road Const. Co.
1,190,633. Process for the separation of asphaltic compounds from gangue. C. L. Cook and J. R. Price.
1,190,642. Asphalt drying, heating, and mixing plant. C. E. Guelich, assignor to Guelich Paving Process Co., Huron, S. D.
1,191,155. Road drag. B. I. Church.
1,191,303. Method of making pavement. W. E. Hassam and H. Parker, assignors to Hassam Paving Co.
1,191,607. Spreader valve and pipe for oil distribution. E. L. Mills.
1,192,099. Fire-brick and method of making same. S. H. Nordin.
1,192,178. Method of treating roadways. S. E. Finley.
1,192,506. Curb guard and anchoring and positioning device therefor. A. E. Davis.
1,193,225. Road or highway. J. S. Blankinship.
1,193,459. Machine for spreading asphalt, etc. J. O. Fraisher.
1,193,515. Road construction. F. E. Clark.
1,193,921. Road drag. G. A. Pollard.
1,193,938. Non-slipping paving composition. P. F. Solan and H. S. Balliet.
1,194,063. Stone spreader. N. E. Pope.
1,195,273. Street-pavement and the method of constructing the same. J. Scheerer.
1,195,344. Road working machine. A. F. Feller and P. P. Musser.
1,195,368. Expansion joint for concrete pavements or the like. E. M. Laing.
1,195,402. Railroad crossing. H. Rust.
1,195,689. Curb plate. G. A. Kneese and R. A. Klassen.
1,197,069. Road drag attachment. W. R. Schmitt.
1,197,528. Drag. H. D. Miller.
1,197,779. Snow plow. F. Stenson.
1,197,948. Road drag. W. Peltier.
1,198,107. Pavement. W. F. Chapman.
1,198,306. Wood flooring. D. A. Young.
1,198,320. Road grader. C. M. Brown and E. W. Patrick.
1,198,355. Ditcher and grader. E. B. Kearns.
1,198,576. Road planer and surfacer. F. Rawlings.
1,198,631. Process and apparatus for laying pavements. I. J. Hartfeld.
1,198,684. Combined scraper and roller. R. J. Waugh and F. E. Johnson.
1,198,769. Process of manufacturing an improved bituminous substance. C. Richardson.
1,198,955. Bituminous substance. C. Richardson.
1,199,751. Roadway. C. W. Baker.
1,200,113. Road drag. W. A. Hunter.
1,201,249. Road machine. J. M. Bresee.
1,201,452. Bridge approach. J. W. Fitzgerald.
1,201,755. Vehicle road. C. Peel.
1,201,915. Road drag. M. T. Austin.
1,159,950. Drainage system tester. G. L. Kelly.
1,177,850. Manhole. O. T. Dougherty.
1,202,172. Protecting device for curbs and the like. W. E. Ficklen.
1,202,410. Driveway paving block. B. Nero.
1,202,679. Road machine. W. A. Dean.
1,203,188. Road drag. C. H. Ellis.

1,203.482. Concrete tamper. E. G. Carr.
1,204,245. Concrete tamper. E. G. Carr.
1,204,524. Elastic bituminous spacing plank for pavements. C. N. Forrest.
1,204,951. Curbing block. L. Dargento.
1,205,502. Road scraper. S. Ashcraft.
1,205,853. Road scraper. M. W. Burton.
1,205,948. Machine for treating earthy material with a binder. M. A. Popkess.
1,206,751. Process of and apparatus for making roads. J. D. Clarkson.
1,206,918. Machine for making asphaltic or other mixtures. N. M. Rosendahl.
1,207,297. Paving. F. L. Keppler.
1,207,728. Track. E. Ellingson.
1,209,238. Surfacing mixture for pavements and other structures. Frank H. Welsh.
1,209,713. Curb bar. T. H. Kane.
1,209,843. Railway road crossing. H. C. Innes.
1,210,043. Railway road bed. A. M. Bunn.
1,210,069. Oil distributing apparatus. N. V. Hendricks.
841,188. Device for detecting subterranean waters. A. Schmid.
1,191,316. Road indicator. O. E. Joseph.
1,191,465. Road grader. E. M. Reese.
1,191,870. Apparatus for extracting volatiles from coals, shales, lignite, and similar materials and for refining the same. C. C. Bussey.
1,192,889. Apparatus for use in connection with the distillation of petroleum and products therefrom. J. L. Gray.
1,193,167. Road scraper. H. Martin.
1,193,918. Roadway for vehicles. R. H. Obarr.
1,193,952. Plastic composition for making paving-brick, building-brick, and building tile. Earl V. Wagner.
1,194,400. Road grader. R. C. Leslie and E. J. K. Schmidt.
1,194,750. Asphaltic products and process of making the same. L. Kirschbraun.
1,195,001. Four horse evener. G. O. Gullikson.
1,195,387. Scarifier. F. T. Moyer.
1,195,554. Culvert. J. Jarvey.
1,195,820. Concrete truss girder bridge. J. V. Jenkins and E. J. Creighton.
1,196,954. Road grader. G. M. Huebsch.
1,199,613. Road roller. J. F. Richardson.
1,199,909. Process for producing a new motor spirit. W. Landes.
1,201,249. Road machine. J. M. Bresee.
1,202,881. Excavating apparatus. W. F. Nicodemus.
1,203,040. Grubbing machine. C. W. Nivala.
1,203,188. Road drag. C. H. Ellis.
1,203,292. Liquid fuel furnace. W. A. White.
1,203,328. Concrete mixer. R. C. Heath.
1,203,482. Concrete tamper. E. G. Carr.
1,203,575. Mounting for drums of concrete mixers. E. W. Brackenbury.
1,205,502. Road scraper. S. Ashcraft.
1,205,735. Water-tight cement and process of producing the same. Asmus M. H. Hansen and Martin C. J. Neve.
1,205,853. Road scraper. M. W. Burton.
1,206,187. Gravel conveyor and roller. W. Whitfield.
1,206,751. Process of an apparatus for making roads. J. D. Clarkson.
1,206,879. Permanent river bank pavement. V. A. Mattingley and W. T. Ridley.

1,206,918. Machine for making asphaltic or other mixtures. N. M. Rosendahl.
1,207,297. Paving. F. L. Keppler.
1,207,524. Elastic bituminous spacing plank for pavements. C. N. Forrest.
1,210,517. Road grader. J. J. Nilson.
1,210,735. Road drag, grader, and scraper combined. W. S. Walker.

TREATISES ON ROAD, BRIDGE, AND CULVERT CONSTRUCTION AND ALLIED SUBJECTS[1]

Furnished by the U. S. Office of Public Roads and Rural Engineering.

ADAMS, HENRY. Theory and practice in designing. New York, N. Y. 1911.

ADAMS, HENRY. Reinforced concrete construction in theory and practice, and elementary manual for students and others, by HENRY ADAMS and ERNEST R. MATTHEWS. London, England, 1911.

AGANA, MARCELINO. The value of good roads. From the *Philippine Agricultural Review*, October, 1909. Extract from *Philippine Education*. Vol. VI, no. 1, June, 1909.

AGG, T. R. The construction of roads and pavements. McGraw-Hill Book Company, New York, 1916.

AGG, T. R. and MCCULLOUGH, C. N. An investigation of concrete roadways. Iowa State Highway Commission. Ames, Iowa, 1916.

AITKEN, THOMAS. Irish Roads Improvement Association. Good roads; how to make and how to maintain them. Efficiency with economy. Belfast, Ireland, 1902. Publishers, W. and G. Baird. Contains also: Constitution of Irish Roads Improvement Association.

Road making and maintenance: a practical treatise for engineers, surveyors, and others. With an historical sketch of ancient and modern practice. London, 1907. Charles Griffin and Company.

ALLEN, JAMES LANE. The blue-grass region of Kentucky and other Kentucky articles. New York, N. Y., 1899.

American Academy of Political and Social Science, Philadelphia, Pa. The New South. 1910.

American Highway Association, Washington, D. C. The official good roads year-book of the United States. 1912-13-14-15-16-17.

American Automobile Association, New York, N. Y. The automobile official blue book, 6, vol. New York, N. Y., 1917, also numerous maps. Automobile Blue Book Publishing Company.

American Civil Engineer's Pocketbook. Second edition. New York, N. Y., 1912, John Wiley and Sons.

American Road Builders' Association. Proceedings, 1st–11th. New York N. Y., 1904–1916. Published by the Association, 150 Nassau Street.

American Road Congress, Richmond, Va., 1911. Atlantic City, N. J., 1912, Detroit, Mich., 1913, Atlanta, Ga., 1914, Oakland, 1915. Papers, addresses and resolutions.

American School of Correspondence, Chicago. Bridge engineering: roof trusses; a manual of practical instruction in the calculation and design of steel truss and girder bridges for railroads and highways. By FRANK O. DUFOUR. Chicago, Ill., 1908. Cyclopedia of civil engineering. Vol. 1–8. Chicago, Ill., 1909.

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[1] Only modern works in English, which are easily obtainable, have been given in this list. Articles in periodicals, which are both numerous and valuable, and publications of the various State organizations and federal departments have been excluded.

American Society for Testing Materials. Standard specifications for structural materials. Philadelphia, Pa.

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STATE GEOLOGISTS

Alabama Geological Survey, Dr. Eugene A. Smith, State geologist, University, Alabama.

Arkansas Geological Survey, N. F. Drake, University of Arkansas, Fayetteville, Arkansas.

California State Mining Bureau, F. McN. Hamilton, State mineralogist, San Francisco, California.

Colorado Geological Survey, Prof. R. D. George, Boulder, Colorado.

Connecticut Geological and Natural History Survey, Prof. Herbert E. Gregory, superintendent, Middletown, Connecticut.

Florida Geological Survey, Dr. E. H. Sellards, State geologist, Tallahassee, Florida.

Georgia Geological Survey, Dr. S. W. McCallie, State geologist, Atlanta, Georgia.

Illinois State Geological Survey, F. W. DeWolf, director, Urbana, Illinois.

Indiana Department of Geology and Natural Resources, Edward Barrett, State geologist, Indianapolis, Indiana.

Iowa Geological Survey, George F. Kay, State geologist, Iowa City, Iowa.

Kansas State Geological Survey, Prof. Erasmus Haworth, State geologist, University of Kansas, Lawrence, Kansas.

Kentucky Geological Survey, J. B. Hoeing, director, Frankfort, Kentucky.

Louisiana Soil and Geological Survey. F. V. Emerson, Baton Rouge.

Maryland Geological Survey, Prof. William B. Clark, State geologist, Johns Hopkins University, Baltimore, Md.

Michigan Geological Survey, Roland C. Allen, director, 503 Hollister Block, Lansing, Michigan.

Minnesota Geological Survey, William H. Emmons, State geologist, University of Minnesota, Minneapolis, Minnesota.

Mississippi Geological Survey, Prof. E. N. Lowe, State geologist, Jackson, Mississippi.

Missouri Bureau of Geology and Mines, Prof. H. A. Buehler, director, Rolla, Missouri.

Montana Geological Survey, Dr. J. P. Rowe, State geologist, Missoula, Mont.

Nebraska Geological Survey, Prof. E. H. Barbour, State geologist, University of Nebraska, Lincoln, Nebraska.

New Jersey Geological Survey, Dr. H. B. Kummel, State geologist, Trenton, New Jersey.

New Mexico, University of New Mexico, Prof. Charles T. Kirk, State geologist, Albuquerque, New Mexico.

New York State Education Department, Sciences Division, Dr. John M. Clarke, Director and State geologist, State Museum, Albany, New York.

North Carolina Geological and Economic Survey, Dr. Joseph Hyde Pratt, State geologist, Chapel Hill, North Carolina.

North Dakota Soil and Geological Survey, Mr. Herbert A. Hard, director, Grand Forks, North Dakota.

Ohio Geological Survey, Prof. John A. Bownocker, State geologist, Columbus, Ohio.

Oklahoma Geological Survey, C. W. Shannon, director, Norman, Oklahoma.
Oregon, H. M. Parks, State geologist State Bureau of Mines and Geology,
Pennsylvania Geological and Topographical Commission, Prof. Richard R. Rice, State geologist, Beaver, Pennsylvania.
Rhode Island Natural Resources Survey, Prof. Charles W. Brown, superintendent, Providence, Rhode Island.
South Carolina Geological Survey, Dr. Stephen Taber, State geologist, Columbia, S. C.
South Dakota Department of Geology, Prof. Freeman Ward, State geologist, Vermilion, South Dakota.
Tennessee Geological Survey, Prof. A. H. Purdue, State geologist, Capitol Annex, Nashville, Tennessee. .
Texas Bureau of Economic Geology and Technology, Dr. J. A. Udden, director, Austin, Texas.
Vermont Geological Survey, Prof. George H. Perkins, State geologist, Burlington, Vermont.
Virginia Geological Survey, Dr. Thos. L. Watson, director, Charlottesville, Virginia.
Washington Geological Survey, Prof. Henry Landes, State geologist, University Station, Seattle, Washington.
West Virginia Geological Survey, Prof. I. C. White, State geologist, Morgantown, West Virginia.
Wisconsin State Geological and Natural History Survey, Dr. E. A. Birge, director and superintendent, W. O. Hotchkiss, State geologist, Madison, Wisconsin.
Wyoming Geological Survey, L. W. Trumbull, State geologist, Cheyenne, Wyoming.

RURAL PUBLIC ROADS OF UNITED STATES AT CLOSE OF 1915

Circular 63, United States Department of Agriculture. Prepared by the Division of Road Economics, Office of Public Roads and Rural Engineering.

STATE	TOTAL RURAL ROADS	TOTAL SURFACED ROADS	PERCENTAGE OF ROADS SURFACED	CASH EXPENDITURES FOR ROADS IN 1915	TOTAL STATE FUNDS FOR ROADS TO JANUARY 1, 1916
	miles	*miles*			
Alabama	55,446	5,915	10.7	$4,283,207	$586,405
Arizona	12,075	350	2.9	1,076,178	1,039,388
Arkansas	50,743	1,200	2.3	2,803,000	165,000
California	61,038	13,000	21.3	20,753,281	16,571,091
Colorado	39,691	1,750	4.4	2,193,000	1,024,751
Connecticut	14,061	3,200	22.7	3,484,944	17,019,120
Delaware	3,674	300	8.0	397,500	224,695
Florida	17,995	3,500	19.4	5,501,135	1,135
Georgia	84,770	13,000	15.3	3,700,000	....
Idaho	23,109	950	4.1	1,974,636	572,812
Illinois	94,141	11,000	11.7	9,263,995	1,686,627
Indiana	63,370	27,000	42.6	13,000,000	....
Iowa	106,847	1,000	1.0	13,606,299	255,935
Kansas	111,536	1,250	1.1	5,510,000	30,000
Kentucky	57,916	13,000	22.1	3,122,430	616,715
Louisiana	24,562	2,250	9.1	3,569,709	606,327
Maine	25,528	3,000	11.7	3,293,902	5,865,209
Maryland	16,458	2,950	17.9	5,630,000	17,583,142
Massachusetts	18,681	8,800	46.6	6,557,279	18,999,992
Michigan	74,089	8,600	11.6	10,174,738	3,182,701
Minnesota	93,500	5,500	5.9	8,292,000	4,288,174
Mississippi	45,778	2,500	5.5	2,900,000	....
Missouri	96,124	8,000	8.3	8,369,189	1,791,172
Montana	39,204	775	2.0	3,676,318	34,346
Nebraska	80,338	500	0.6	3,520,000	377,850
Nevada	15,000	75	0.5	250,000	20,000
New Hampshire	14,020	1,800	12.8	2,363,414	3,259,789
New Jersey	14,817	4,600	31.0	7,163,584	8,355,576
New Mexico	11,873	450	3.8	584,919	662,955
New York	80,112	17,500	21.8	24,255,648	96,622,498
North Carolina	50,758	6,500	12.8	5,510,000	38,500
North Dakota	68,000	1,100	1.6	2,500,700	....
Ohio	86,453	30,920	35.8	12,975,688	8,566,275
Oklahoma	107,916	300	0.3	3,410,000	30,323
Oregon	36,819	7,780	21.1	6,182,000	418,975
Pennsylvania	91,556	9,883	10.8	12,541,257	30,801,211
Rhode Island	2,121	1,246	58.8	594,119	3,907,784
South Carolina	42,220	3,500	8.3	1,000,000	....
South Dakota	96,306	850	0.9	1,450,000	....
Tennessee	46,050	8,625	18.7	3,503,500	3,500
Texas	128,960	12,000	9.3	9,500,000	....
Utah	15,000	1,053	7.0	1,213,100	809,732
Vermont	15,082	3,478	23.1	1,475,145	3,671,564
Virginia	53,388	4,760	8.9	4,018,399	2,713,550
Washington	42,428	5,460	12.8	6,670,702	8,552,789
West Virginia	32,024	1,200	3.7	2,759,212	[1]130,978
Wisconsin	75,702	14,050	18.5	9,960,980	4,219,001
Wyoming	14,381	500	3.5	441,291	43,237
Total	2,451,660	276,920	11.3	$266,976,399	$265,350,824

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[1] Of this $118,000 was returned to the counties in 1911 by act of legislature.

REVENUES USED IN 1914 IN EACH STATE FOR PUBLIC ROAD AND BRIDGE PURPOSES AND TOTAL OUTSTANDING BONDS FOR ROADS AND BRIDGES AT CLOSE OF 1914

From Bulletin 390, U. S. Department of Agriculture, Prepared by the Office of Public Roads and its State Collaborators

STATE	PUBLIC ROAD AND BRIDGE REVENUES					TOTAL STATE AND LOCAL BONDS
	Total	Per mile of road	Per square mile	Per capita	Per $100 assessed valuation	
Alabama	$3,949,019.00	$71.22	$77.01	$1.840	$0.6900	$5,418,000.00
Arizona	982,721.22	81.38	8.63	4.810	0.7000	295,000.00
Arkansas	1,522,696.20	30.00	28.99	0.960	0.3600	1,467,066.00
California	19,171,984.66	314.09	123.17	8.060	0.6600	32,277,000.00
Colorado	1,937,546.23	48.70	18.69	2.420	0.4600	90,500.00
Connecticut	3,640,962.75	258.90	755.50	3.260	0.3500	7,000,000.00
Delaware	511,628.00	139.25	260.37	2.520	0.5450	1,280,000.00
Florida	2,280,255.09	126.71	41.56	3.020	1.0700	5,959,199.00
Georgia	3,688,172.25	45.72	62.80	1.410	0.4370	127,500.00
Idaho	1,371,468.59	56.22	16.45	4.210	0.8200	1,339,000.00
Illinois	8,734,712.77	91.32	155.85	1.540	0.3700	798,761.55
Indiana	14,233,985.93	194.06	394.89	5.270	0.7500	42,095,357.34
Iowa	10,187,507.32	97.88	183.27	4.580	1.1300	1,960,780.00
Kansas	5,544,048.00	49.92	67.79	3.280	0.2000	....
Kentucky	2,474,621.00	42.52	61.58	1.080	0.2390	705,000.00
Louisiana	1,777,572.12	72.37	39.10	1.073	0.3220	1,588,835.00
Maine	2,642,006.79	112.25	88.37	3.550	0.6330	785,000.00
Maryland	6,000,652.03	364.60	603.62	4.630	0.4850	12,853,700.00
Massachusetts	6,091,875.30	326.08	758.00	1.810	0.1270	10,305,522.82
Michigan	9,261,998.00	124.84	161.13	3.290	0.4000	10,389,029.43
Minnesota	6,458,940.07	69.06	79.88	3.110	0.4400	1,411,889.00
Mississippi	3,960,377.00	86.51	85.42	2.200	0.9620	8,327,172.00
Missouri	5,513,048.71	57.40	80.22	1.670	0.3000	522,500.00
Montana	2,888,400.61	73.67	19.75	7.680	0.8300	2,224,050.72
Nebraska	1,796,277.69	22.37	23.38	1.510	0.3900	....
Nevada	245,013.65	20.11	2.23	2.990	0.2400	38,000.00
New Hampshire	1,590,464.11	113.44	176.11	3.690	0.3620	675,000.00
New Jersey	7,208,287.08	486.49	959.00	2.830	0.2890	14,011,337.00
New Mexico	556,398.82	46.86	4.54	1.690	0.7700	157,000.00
New York	23,231,964.02	292.60	467.00	2.540	0.2080	76,822,088.00
North Carolina	5,215,490.78	102.75	107.00	2.360	0.6970	8,955,300.00
North Dakota	2,402,383.52	34.92	34.23	4.160	0.6800	....
Ohio	14,334,245.98	165.99	351.84	3.000	0.2200	31,175,968.53
Oklahoma	2,112,680.80	19.57	30.45	1.274	0.1769	1,440,000.00
Oregon	5,310,466.76	144.23	55.54	7.890	0.5900	1,615,000.00
Pennsylvania	10,424,580.00	113.86	232.00	1.360	0.2050	27,547,659.00
Rhode Island	446,496.05	205.76	418.50	0.820	0.0720	1,800,000.00
South Carolina	1,024,480.37	24.26	33.59	0.670	0.3510	460,000.00
South Dakota	1,217,809.42	12.64	15.84	2.080	0.3400	....
Tennessee	2,370,560.16	51.48	56.86	1.080	0.3780	6,898,277.00
Texas	9,920,079.11	76.92	37.80	2.540	0.3910	14,615,017.00
Utah	803,070.63	91.15	9.77	2.150	0.4000	541,500.00
Vermont	1,023,941.01	71.86	112.22	2.870	0.4620	....
Virginia	3,224,528.82	60.39	80.08	1.560	0.3720	5,650,994.93
Washington	7,944,717.38	187.25	118.87	6.950	0.7900	1,555,000.00
West Virginia	2,483,747.00	77.55	103.39	2.030	0.2120	1,303,000.00
Wisconsin	9,880,240.50	130.50	178.81	4.230	0.4000	281,078.00
Wyoming	669,661.16	44.06	6.86	4.590	0.3700	....
Total or ave.	$240,263,784.46	$98.22	$80.79	$2.620	$0.3500	$344,763,082.32

EXTENT OF SURFACED ROADS IN THE UNITED STATES AT THE CLOSE OF 1914

From Bulletin 390, U. S. Department of Agriculture, Prepared by the Office of Public Roads and its State Collaborators

STATE	MACADAM	BITUMINOUS MACADAM	GRAVEL	SAND CLAY	BRICK	CONCRETE	MISCELLANEOUS	TOTAL SURFACED
	miles	*miles*	*miles*	*miles*	*miles*	*miles*	*miles*	*miles*
Alabama	431.00	31.00	2,589.50	1,916.00		1.00	20.00	4,988.50
Arizona	11.23	13.50	125.70	45.00			58.00	253.43
Arkansas	362.50	4.00	535.00	175.00		21.00		1,097.50
California	837.40	877.90	3,563.59	582.25		929.19	3,489.40	10,279.73
Colorado	3.00		574.25	450.12		2.25	164.25	1,193.87
Connecticut	923.42	128.28	1,057.93	840.27	1.33	24.22		2,975.45
Delaware	161.50	35.50	21.00				25.50	243.50
Florida	829.16	42.80	42.50	1,163.00	256.24	12.00	484.77	2,830.47
Georgia	234.00	87.00	1,073.00	10,778.00	1.72	.40	168.00	12,342.12
Idaho	42.50	12.00	168.00	449.00		4.50	3.00	679.00
Illinois	1,675.11	121.53	7,052.30	2,467.95	82.92	148.80	57.70	11,606.31
Indiana	10,291.29	168.35	20,264.59	150.25	34.75	53.17		30,962.40
Iowa	171.30		413.00	23.00		5.77	1.50	614.57
Kansas	194.30		151.85	758.50	4.10	1.35	38.75	1,148.85
Kentucky	10,628.00	59.03	1,713.50		.25	2.50		12,403.28
Louisiana			430.00	1,448.00			189.62	2,067.62
Maine	55.36	43.93	1,139.36	2.26	.05	10.51	1,510.89	2,762.36
Maryland	488.70	1,042.31	243.95	69.00		189.34	455.96	2,489.26
Massachusetts	834.30	1,337.33	6,289.57				44.69	8,505.89
Michigan	1,021.19	94.50	5,230.25	1,375.27		107.30		7,828.51
Minnesota	120.25	19.00	2,825.25	985.33	.50	17.50		3,967.83
Mississippi	86.00	29.50	1,281.10	604.25		14.00	118.50	2,133.35
Missouri	1,531.05	59.00	3,671.50	1,442.25	1.00	2.77	5.00	6,712.57
Montana	78.00		514.25	14.00			3.00	609.25
Nebraska	89.21	1.30	21.00	1,131.10	2.40	7.53	2.00	1,254.54
Nevada	2.00		193.00	67.00				262.00
New Hampshire	61.87	154.26	1,013.70	270.90		7.07	151.83	1,659.63
New Jersey	1,809.24	417.63	2,858.52	561.40			250.67	5,897.46
New Mexico		5.00	184.00	72.50				261.50
New York	5,717.97	3,168.63	5,802.97		148.53	244.19	553.61	15,635.90
North Carolina	1,111.00	9.00	529.00	4,313.50		1.25	40.00	6,003.75
North Dakota			955.00					955.00
Ohio	12,903.87	1,066.29	15,385.93	211.00	640.41	315.67	46.00	30,569.17
Oklahoma	6.70	3.00	6.90	105.00				121.60
Oregon	1,000.72	137.25	3,060.15	300.00		28.41	199.87	4,726.40
Pennsylvania	1,881.80*	198.33*	235.19*		269.33*		7,398.23	982.88
Rhode Island	352.92	107.40	230.10				3.00	693.42
South Carolina	27.50	3.50	85.00	3,101.00			53.50	3,270.50
South Dakota		10.00	212.00	129.00			12.00	363.00
Tennessee	4,550.50	148.00	2,788.00	613.00	.50	2.00		8,102.00
Texas	511.00	181.00	5,258.98	3,490.48		11.25	1,074.08	10,526.79
Utah	49.00	15.50	685.75	401.00		2.50		1,153.75
Vermont	1.94		1,165.42				274.67	1,442.03
Virginia	1,177.89	255.77	822.09	1,511.65			142.17	3,909.57
Washington	502.82	165.52	3,924.48	83.50	26.35	79.42	140.00	4,922.09
West Virginia	771.92	62.95	20.50		121.10	18.50	70.00	1,064.97
Wisconsin	1,408.00	183.00	9,597.00	2,054.00	2.40	83.07	72.00	13,399.47
Wyoming			52.50				416.00	468.50
Total	64,898.43	10,499.79	116,058.12	44,154.73	1,593.88	2,348.43	17,738.16	257,291.54
Per cent	25.22	4.08	45.11	17.16	0.62	0.91	6.90	100.00

* State roads only.

MOTOR-CAR REGISTRATIONS AND GROSS MOTOR-VEHICLE REVENUES, 1913-1915

Circular 59, United States Department of Agriculture. Prepared by the Division of Road Economics, Office of Public Roads and Rural Engineering

	MOTOR-CAR REGISTRATIONS[1]			TOTAL GROSS REVENUES		
	1913	1914	1915	1913	1914	1915
Alabama........	[2]5,300	8,672	11,634	$83,000	$113,202	$180,744
Arizona.........	3,613	5,040	7,753	27,545	34,077	45,579
Arkansas........	3,583	5,642	8,021	17,411	56,420	80,551
California.......	[2]100,000	123,504	163,797	75,000	1,338,785	2,027,432
Colorado........	13,000	17,756	28,894	60,833	80,047	120,801
Connecticut.....	23,200	27,786	41,121	316,667	406,623	536,970
Delaware.......	2,440	3,050	5,052	24,735	35,672	55,596
District of Columbia........	4,000	4,833	8,009	13,228	20,147	29,396
Florida.........	[4]3,000	[4]3,368	[2]10,850	[4]6,000	[4]6,736	[2]60,000
Georgia.........	[2]20,000	20,915	25,000	12,000	104,575	125,000
Idaho...........	2,113	3,346	7,071	35,160	58,580	121,259
Illinois..........	94,656	131,140	180,832	507,629	699,725	924,906
Indiana	45,000	66,500	96,915	150,345	432,309	587,318
Iowa............	70,299	106,087	145,109	787,411	1,040,136	1,533,054
Kansas.........	34,550	49,374	72,520	186,066	268,471	387,588
Kentucky.......	7,210	11,766	19,500	52,000	85,883	117,117
Louisiana.......	[2]10,000	[2]12,000	11,380	[2]10,000	[2]12,000	75,600
Maine..........	11,022	15,700	21,545	138,509	192,542	268,412
Maryland.......	14,217	20,213	31,047	150,000	268,231	386,565
Massachusetts..	62,660	77,246	102,633	764,154	923,961	1,235,724
Michigan.......	54,366	76,389	114,845	190,329	([3])	373,833
Minnesota......	46,000	67,862	93,269	40,000	132,398	[2]160,540
Mississippi......	[2]3,850	5,694	9,669	....	51,146	76,700
Missouri........	38,140	54,468	76,462	173,510	235,873	323,289
Montana........	5,916	10,200	14,540	12,000	27,000	33,120
Nebraska.......	13,411	16,385	59,000	26,000	34,325	[2]183,000
Nevada.........	1,091	1,487	2,009	3,323	4,331	7,875
New Hampshire	8,237	9,571	13,449	152,834	185,288	257,776
New Jersey.....	51,360	62,961	81,848	661,446	814,536	1,062,923
New Mexico....	1,898	3,090	5,100	15,084	19,663	29,625
New York......	134,495	168,223	255,242	1,275,727	1,529,852	1,991,181
North Carolina.	10,000	14,677	21,000	60,000	89,580	123,000
North Dakota...	15,187	17,347	24,908	41,961	55,964	79,245
Ohio............	86,156	122,504	181,332	457,538	685,457	984,622
Oklahoma.......	[2]3,000	13,500	25,032	3,000	13,500	154,892
Oregon..........	13,975	16,447	23,585	56,873	77,592	108,881
Pennsylvania...	80,178	112,854	160,137	841,062	1,185,039	1,665,276
Rhode Island...	10,295	12,331	16,362	129,851	157,020	206,440
South Carolina[2].	10,000	14,000	15,000	10,000	14,000	15,000
South Dakota...	14,457	20,929	28,724	89,170	125,000	[2]180,000

Motor-Car Registrations—Continued

	MOTOR-CAR REGISTRATIONS[1]			TOTAL GROSS REVENUES		
	1913	1914	1915	1913	1914	1915
Tennessee.......	[2]10,000	[5]19,769	[6]7,618	[2]9,000	39,538	[2]34,000
Texas[2]..........	32,000	40,000	[7]40,000	16,000	20,000	20,000
Utah............	4,000	2,253	9,177	3,000	4,852	[2]60,000
Vermont........	5,913	8,475	11,499	111,460	154,267	218,480
Virginia........	9,022	13,984	21,357	83,611	120,814	176,875
Washington.....	24,178	30,253	38,823	48,356	60,506	238,717
West Virginia...	5,144	6,159	13,279	40,000	60,648	128,952
Wisconsin......	34,346	53,161	79,741	190,770	293,580	431,977
Wyoming.......	1,584	2,428	3,976	7,920	12,140	19,880
Total.........	1,258,062	1,711,339	2,445,664	8,192,253	12,381,951	18,245,711

[1] Does not include motor cycles nor dealers' and manufacturers' licenses.
[2] Estimated.
[3] Registration law declared unconstitutional.
[4] State registrations only.
[5] Total cars registered under perennial system.
[6] Registrations 1915 only.
[7] American Highway Association received report that there were 138,866 automobiles licensed on April 1, 1916.

PRODUCTION OF VITRIFIED PAVING BRICK IN THE UNITED STATES

(*From "Mineral Resources of the United States, 1915"*)

YEAR	QUANTITY	VALUE	AVERAGE PRICE PER THOUSAND
	thousands		
1895	381,591	$3,130,472	$8.20
1896	320,407	2,794,585	8.72
1897	435,851	3,582,037	8.22
1898	474,419	4,016,822	8.47
1899	580,751	4,750,424	8.18
1900	546,679	4,764,124	8.71
1901	605,077	5,484,134	9.06
1902	617,192	5,744,530	9.31
1903	654,499	6,453,849	9.86
1904	735,489	7,557,425	10.28
1905	665,879	6,703,710	10.07
1906	751,974	7,857,768	10.45
1907	876,245	9,654,282	11.02
1908	978,122	10,657,475	10.90
1909	1,023,654	11,269,586	11.01
1910	968,000	11,004,666	11.37
1911	948,758	11,115,742	11.72
1912	911,869	10,921,575	11.98
1913	958,680	12,138,221	12.66
1914	931,324	12,500,866	13.42
1915	953,335	12,230,899	12.83

OUTPUT OF VITRIFIED BRICK IN 1914 AND 1915 BY STATES

(From "Mineral Resources of the United States, 1915")

	1914			1915		
	Quantity	Value	Average price per thousand	Quantity	Value	Average price per thousand
	thousands			*thousands*		
Alabama	18,679	$248,525	$13.31	29,018	$374,387	$12.90
Arkansas	*	*	12.14	*	*	12.00
California	1,800	39,705	22.06	3,182	66,784	20.99
Colorado	*	*	11.52	*	*	11.59
Connecticut and Rhode Island	*	*	16.03	*	*	12.66
Florida	*	*	12.00			
Georgia	16,470	234,855	14.26	17,193	166,086	9.66
Illinois	157,176	2,086,344	13.27	142,689	1,796,350	12.59
Indiana	42,937	576,892	13.44	35,237	466,873	13.25
Iowa	14,997	211,905	14.13	20,573	300,785	14.62
Kansas	50,707	594,229	11.72	47,511	608,599	12.81
Kentucky	*	*	12.74	*	*	10.85
Michigan	7,733	120,562	15.59	4,420	62,238	14.08
Minnesota	*	*	16.12	*	*	14.18
Missouri	26,217	424,170	16.18	*	*	14.62
Montana	*	*	22.50	*	*	22.01
Nebraska	*	*	11.14	561	8,323	14.84
New Jersey	*	*	15.00			
New Mexico	*	*	10.40	*	*	12.00
New York	31,240	515,672	16.51	24,154	384,458	15.92
Ohio	293,381	3,682,230	12.55	333,288	4,017,758	12.05
Oklahoma	9,912	127,792	12.89	16,537	198,387	12.00
Pennsylvania	151,200	2,052,676	13.58	124,354	1,638,518	13.18
Tennessee	*	*	15.26	*	*	14.47
Texas	1,684	23,599	14.01	*	*	15.45
Virginia	*	*	10.00			
Washington	*	*	18.99	14,861	265,691	17.88
West Virginia	67,750	899,215	13.27	69,474	841,067	12.11
Other States†	39,441	662,495	16.80	59,844	853,107	14.26
Total	931,324	$12,500,866	$13.42	953,335‡	$12,230,899‡	$12.83

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* Included in "Other States."

† Includes all products made by less than three producers in one State.

‡ In the total quantity and total value of vitrified brick are included, respectively, 824,359,000 vitrified brick sold for paving, valued at $11,114,427, and 128,976,000 vitrified brick sold for other uses, valued at $1,116,472.

BROKEN STONE FOR ROAD BUILDING PRODUCED IN THE UNITED STATES IN 1914 AND 1915

(*From "Stone in 1915," G. F. Loughlin, "Mineral Resources of the United States*

STATE OR TERRITORY	1914		1915	
	Quantity	Value	Quantity	Value
	Short tons		*Short tons*	
Alabama	74,914	$75,528	49,972	$42,116
Arizona	2,600	4,000	....	....
Arkansas	199,417	140,442	113,606	75,044
California	1,707,230	982,321	1,567,505	902,462
Colorado	6,052	10,100	5,842	7,178
Connecticut	360,443	216,064	728,014	330,174
Delaware	53,430	33,501	21,742	21,707
Florida	159,524	84,911	102,517	56,381
Georgia	57,553	37,088	90,244	54,696
Hawaii	41,832	37,049	34,413	36,366
Idaho	....	....	....	....
Illinois	1,838,599	893,889	1,625,250	747,718
Indiana	2,089,103	1,065,360	1,792,261	910,462
Iowa	19,308	17,438	32,437	28,397
Kansas	27,248	20,135	20,046	15,591
Kentucky	545,878	323,075	609,995	379,234
Louisiana	....	....	830	664
Maine	5,950	4,650	1,747	1,409
Maryland	404,523	349,833	334,153	274,644
Massachusetts	649,144	594,666	738,015	599,555
Michigan	530,823	267,702	510,524	224,734
Minnesota	46,944	46,172	59,733	57,286
Missouri	466,143	363,302	553,049	383,022
Montana	4,590	1,271	23,875	5,186
Nebraska	32,137	27,300	....	....
New Hampshire	20,936	13,745	14,845	12,416
New Jersey	827,705	674,202	1,059,749	822,214
New Mexico	....	....	547	407
New York	2,267,264	1,408,490	2,900,165	1,623,570
North Carolina	65,700	65,128	69,238	73,404
Ohio	3,453,360	1,748,075	3,088,599	1,567,676
Oklahoma	15,802	7,441	46,430	29,764
Oregon	218,379	157,267	290,648	202,580
Pennsylvania	1,640,049	1,110,039	1,844,626	1,218,446
Rhode Island	61,373	72,255	91,872	110,167
South Carolina	28,425	27,684	27,111	26,566
South Dakota	14,120	11,300	11,292	8,487
Tennessee	345,765	264,288	441,298	369,296
Texas	196,051	119,218	269,151	164,865
Utah	16,000	19,200	6,500	3,750
Vermont	17,978	13,563	14,929	13,269
Virginia	1,931,852	1,185,271	2,193,898	1,538,149
Washington	162,777	87,259	213,039	111,461
West Virginia	197,245	113,525	196,068	129,106
Wisconsin	1,000,667	635,618	914,295	555,927
Wyoming	....	....	....	....
	21,786,833	13,329,365	22,710,070	13,735,546

GRAVEL AND PAVING SAND PRODUCED IN THE UNITED STATES IN 1914 AND 1915

R. W. Stone in "Mineral Resources of the United States, 1915"

STATE	PAVING SAND				GRAVEL			
	1914		1915		1914		1915	
	Quantity (short tons)	Value	Quantity (short tons)	Value	Quantity (short tons)	Value	Quantity (short tons)	Value
Alabama	5,849	$4,538	*	*	527,891	$138,693	547,656	$116,672
Arizona	....	....	....	....	....	....	*	*
Arkansas	*	*	....	....	673,924	278,876	831,668	314,003
California	106,578	26,714	173,985	$42,841	3,258,718	595,449	2,974,090	709,602
Colorado	....	....	*	*	7,610	3,310	*	*
Connecticut	*	*	....	....	....	....	*	*
Florida	29,000	7,000	*	*	98,435	10,637	16,518	4,495
Georgia	5,610	1,400	*	*	12,244	7,875	22,848	15,071
Hawaii	....	....	....	....	....	....	*	*
Idaho	....	....	....	....	*	*	*	*
Illinois	121,812	39,851	291,436	73,645	4,955,219	793,422	4,424,527	885,548
Indiana	158,443	55,290	240,053	66,894	4,184,093	602,533	2,482,922	591,592
Iowa	201,900	64,340	293,948	97,008	1,087,967	205,820	1,554,199	313,327
Kansas	137,582	37,206	244,103	70,311	160,283	19,512	*	*
Kentucky	21,653	14,272	*	*	815,796	208,770	448,897	162,534
Louisiana	*	*	*	....	738,510	190,717	*	*
Maine	....	....	....	....	*	*	*	*
Maryland	327,750	76,212	163,304	71,517	760,204	268,338	854,180	284,410
Massachusetts	78,380	33,161	47,239	25,444	177,642	50,795	270,906	169,772
Michigan	320,322	74,866	131,466	14,021	2,140,359	530,338	2,457,094	671,970
Minnesota	36,458	15,666	*	*	637,900	236,704	985,252	175,084
Mississippi	....	....	*	*	1,500,291	354,855	991,119	153,627
Missouri	30,327	6,485	*	*	1,321,839	257,827	1,656,745	226,716
Montana	*	*	*	*	13,310	11,970	7,422	5,500
Nebraska	5,259	610	*	*	88,026	16,435	118,970	27,389
Nevada	....	....	....	....	*	*	17,491	1,775
New Hampshire	....	....	....	....	670,000	112,500	583,200	77,760
New Jersey	110,260	39,902	160,256	53,599	2,204,880	672,433	2,112,557	447,388
New Mexico	....	....	*	*	*	*	*	*
New York	82,725	34,148	51,363	21,240	2,149,310	891,762	2,828,887	989,801
North Carolina	....	....	....	....	311,059	42,438	77,241	23,652
North Dakota	....	....	....	....	10,875	5,725	*	*
Ohio	407,025	134,370	501,359	194,026	2,417,805	654,833	2,816,132	922,379
Oklahoma	....	....	....	....	505,737	225,559	*	*
Oregon	3,368	2,607	15,218	14,174	611,821	137,221	368,797	118,960
Pennsylvania	625,171	235,826	291,599	106,828	1,766,651	387,845	1,814,902	433,223
Rhode Island	....	....	....	....	*	*	*	*
South Carolina	....	....	....	....	29,927	4,995	*	*
South Dakota	*	*	*	*	196,909	25,603	239,649	36,826
Tennessee	6,489	2,484	13,815	3,552	445,504	183,296	540,653	203,867
Texas	46,460	14,315	11,904	2,950	1,183,646	433,399	1,494,421	393,121
Utah	44,445	11,300	*	*	184,763	45,162	251,216	29,772
Vermont	....	....	....	....	822	390	*	*
Virginia	*	*	*	*	294,398	87,379	519,850	126,801
Washington	363,745	86,796	83,827	27,628	457,137	162,183	478,707	129,016
West Virginia	44,617	17,819	69,598	27,230	455,804	125,618	114,273	43,016
Wisconsin	222,298	71,560	206,094	67,340	1,294,893	343,230	1,567,840	349,941
Wyoming	....	....	....	....	718,441	48,245	*	*
Concealed totals	36,645	13,761	391,150	97,138	142,215	26,205	1,551,719	443,791
	3,580,171	1,121,999	3,381,717	1,077,346	39,212,858	9,398,897	37,972,548	9,598,391

* Included in "Concealed totals."

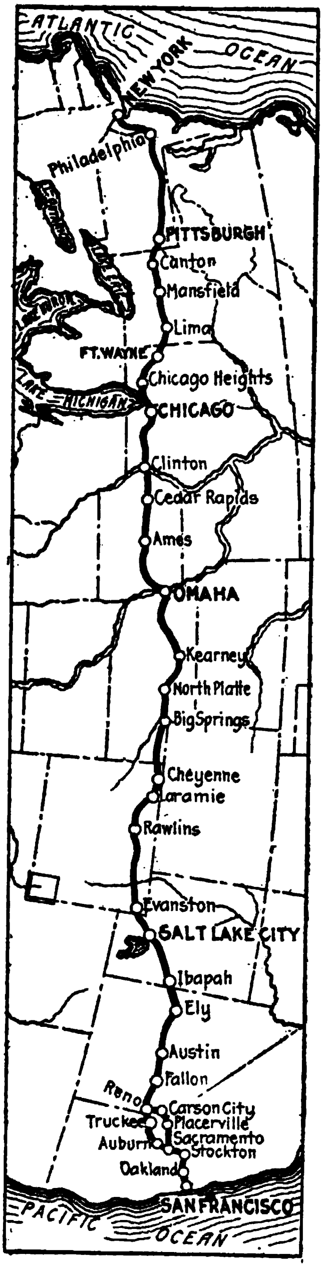
MARKED HIGHWAY ROUTES

For a number of years, associations have been increasing rapidly in number which have for their object the improvement of highways ranging in length from roads connecting adjacent county seats to transcontinental routes. Usually these routes are marked more or less fully by colored bands on poles, fences and bridges, so that the traveler can follow them easily. The leading through routes in a few States have been marked in this manner by the State highway departments. So many of these routes were promoted in Iowa that a law was passed in 1913 enabling an association promoting any route to register it. This law reads as follows:

> Any association organized to promote the improvement of any continuous highway not less than 25 miles in length may, by making application to the State highway commission, register in the office of said commission the name, detailed route, color combination and design used in marking said route. The highway commission shall have power to determine priority of right in the use of the said name, color combination and designs.
>
> The application shall be in the form prescribed by the commission upon blanks furnished by it, and shall be properly acknowledged by the president and secretary of the association before a notary. Said application shall be accompanied by a registration fee of $5, which fee shall be returned to the association if the application be not granted.
>
> If the State highway commission shall, after investigation, adjudge the application meritorious and the route to be worthy of the protection of this act, it shall issue to the association a certificate which shall designate in detail the name, the starting and the terminal points, the color combination and designs used in marking the route; all of which facts shall be recorded as a part of the permanent records of the commission in a book kept for that purpose.
>
> It shall be unlawful for any person or association of persons to use for similar purposes the name, any recorded color combination and designs herein referred to.
>
> Any person who shall injure or deface any sign board, design or other markings designating routes, shall be subject to the provisions of Section 4801 of the code.
>
> When any such highway association ceases to exist or when the interest in the route, name and markings has ceased, the State highway commission may, after proper investigation, cancel the records and registration herein referred to and reassign the name, color combination, designs or other markings to any association making application for their use.
>
> All fees received by the State highway commission under this act shall be turned into the State treasury.
>
> Any person or officer of any association violating any of the provisions of this act shall be guilty of a misdemeanor.

There have been nearly one hundred of these routes promoted in Iowa, but only a few of them have been registered. Nearly fifty routes have been marked in Illinois. In both states the marking of the routes has the approval of the State highway department. In a few states opposition has been shown to the practice on the ground that all signs on the right-of-way should be placed and maintained by the public officials.

Lincoln Highway Association



LINCOLN HIGHWAY

Officers.—President, Henry B. Joy, Detroit; vice-presidents, Roy D. Chapin, Detroit, and Carl G. Fisher, Indianapolis; secretary, A. F. Bement, Detroit; field secretary, H. C. Ostermann, Detroit; treasurer, Emory W. Clark, Detroit; directors, the preceding and John N. Willys, Toledo, A. Y. Gowan, Chicago, F. A. Sieberling, Akron, Paul H. Deming, Detroit, S. D. Waldon, Detroit, Russell A. Alger, Detroit, Albert Beveridge, Indianapolis, James A. Allison, Indianapolis.

The proposal to mark a highway route from the Atlantic to the Pacific, to be known as the Lincoln Highway, was first made by Carl G. Fisher, of Indianapolis, in 1913. He secured the coöperation of prominent business men, and they organized the Lincoln Highway Association in that year. It is not a constructing organization, but its purpose is to secure the expenditure of State, county and local road funds on the route. Where road improvement is left to the public authorities, gaps are sometimes left in through routes; this has been the case with the Lincoln Highway, and the association has raised funds to construct some sections which local resources were inadequate to build.

Just how much improvement work has been done on the Lincoln Highway cannot be determined accurately. The association estimates that during 1914 and 1915, over $3,000,000 was spent on construction and about $6,000,000 in 1916.

The route is about 3,300 miles long. From New York to Nebraska, existing main roads afforded direct connections between successive cities. In Nebraska roads on section lines and consequently both angular and long have been straightened.

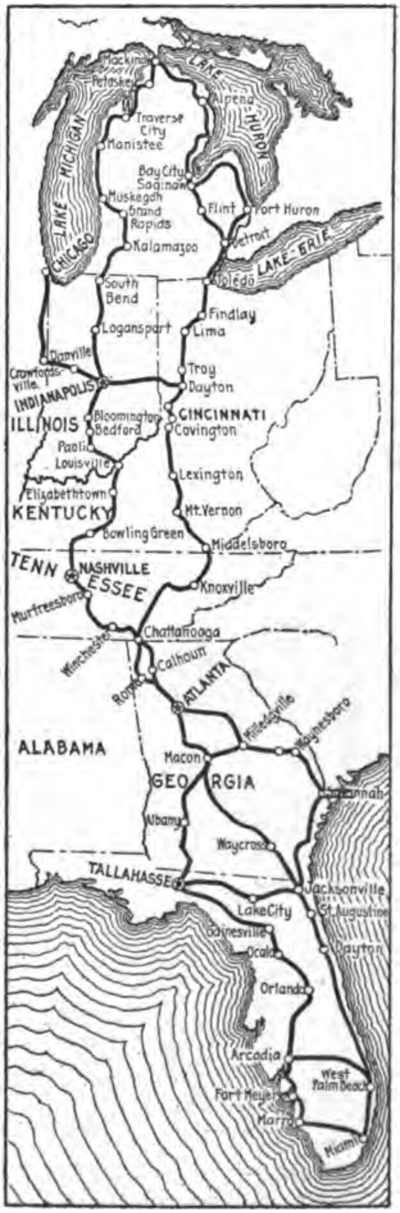
Dixie Highway Association

Officers.—President, M. M. Allison, Chattanooga, Tenn.; vice president, C. H. Huston, Chattanooga, Tenn.; secretary-treasurer, W. R. Long, Chattanooga, Tenn.; the president, secretary-treasurer, Carl G. Fisher, Indianapolis, Richard Hardy, Chattanooga, and Clark Howell, Atlanta; State vice-presidents, P. T. Colgrove, Hastings, Mich.; Richard J. Finnegan, Chicago, Ill., Thomas Taggart, French Lick, Ind.; Harry L. Gordon, Cincinnati, Ohio; H. B. Hanger, Richmond, Ky.; W. T. Anderson, Macon, Ga.; G. W Saxon, Tallahassee, Fla.

This association was organized in 1915 at a conference of the governors of the States traversed by the highway, and was suggested by Clark G. Fisher, of Indianapolis. The State vice-presidents and directors are appointed by the governors of the States.

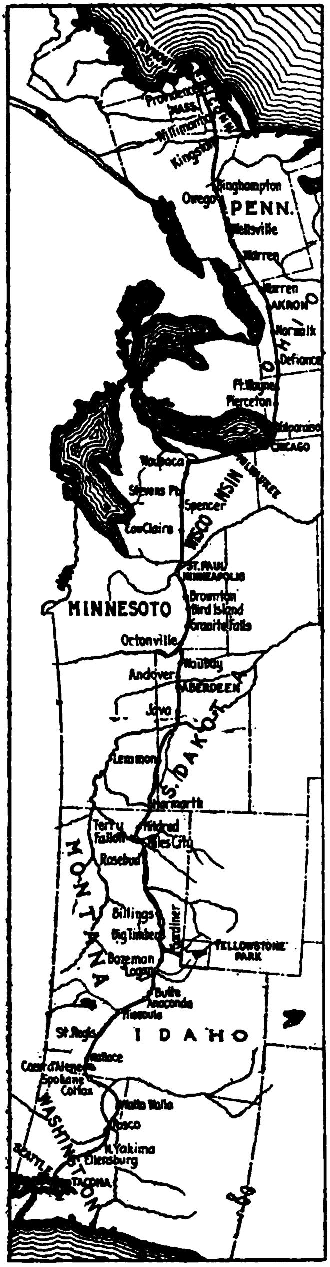
The route is approximately 4500 miles long and traverses 163 counties. Construction is in progress along the entire stretch, but during the winter of 1916–17 heavy rains rendered parts of the highway impassable until they dried out. The worst sections in February, 1917, were between Lexington, Ky., and Knoxville, Tenn.; Nashville and Chattanooga, Tenn.; Tallahassee and Gainesville, Fla., and eastward from Arcadia, Fla.

The association publishes the *Dixie Highway*, a monthly, for the purpose of attracting attention to the interesting features of the country through which the road passes. It also maintains an information bureau at 1012 Georgia Avenue, Chattanooga, for advising travelers concerning the condition of all parts of the road and the detours that should be made to avoid sections under construction or in poor condition.



DIXIE HIGHWAY

Yellowstone Trail Association



YELLOWSTONE TRAIL

Officers.—President J. W. Parmley, Ipswich, S. D.; vice-presidents, M. J. Dowling, Olivia, Minn., and F. E. Stone, Wallace, Idaho; secretary and general agent, H. O. Cooley, Aberdeen, S. Dak.; treasurer, M. P. Beebe, Ipswich, S. D.; office secretary, M. H. Doyle, Aberdeen, S. Dak.; executive committee, the president, vice-presidents, Floyd Tifft, Colfax, Wash.; Bud Story, Bozeman, Mont.; G. H. Sult, Marmarth, N. Dak.; Anton Karpen, Webster, S. Dak.; G. A. Will, Minneapolis, Minn.; Erle Whipple, Waupaca, Wis.; J. T. Brown, Chicago, Ill. Offices at Aberdeen, S. D.

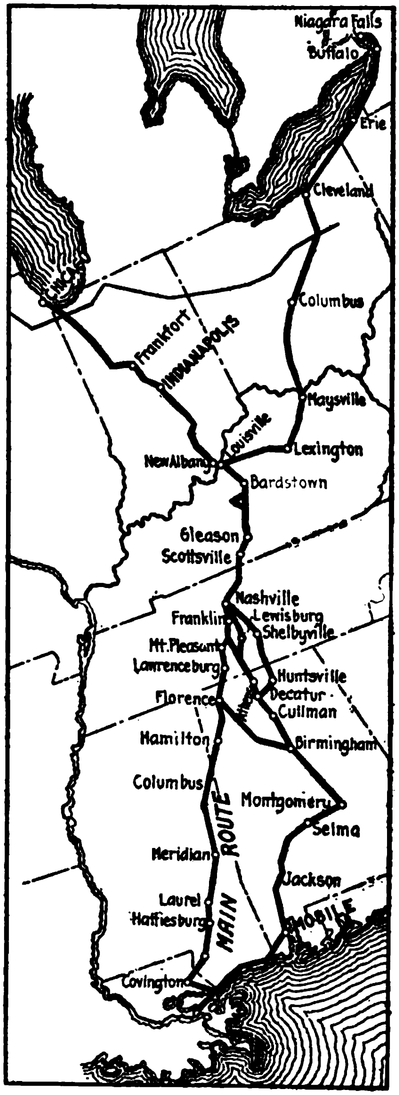
In a paper on the value of permanent highways for national defense, Major Amos A. Fries, Corps of Engineers, U. S. A., made the following comment on this and other routes:

"Fine roads along our coasts and land boundaries will be of the most immediate military benefit, and should be of the widest and best, since they will have to bear the heaviest and most concentrated traffic. There are a number of roads proposed or actually under construction that come under this head. Such are the Pacific Highway along or near the Pacific coast from Seattle to San Diego, the Yellowstone Trail along the northern border from the vicinity of the Great Lakes to the Columbia River, and the Lincoln Highway across the north central part of the United States. While highways intended primarily for military purposes should be located near our borders, north, east, south and west, they must not be so near that they can be easily raided or captured by comparatively small bodies of the enemy and thus likely to be of use only to him and not to us."

Jackson Highway Association

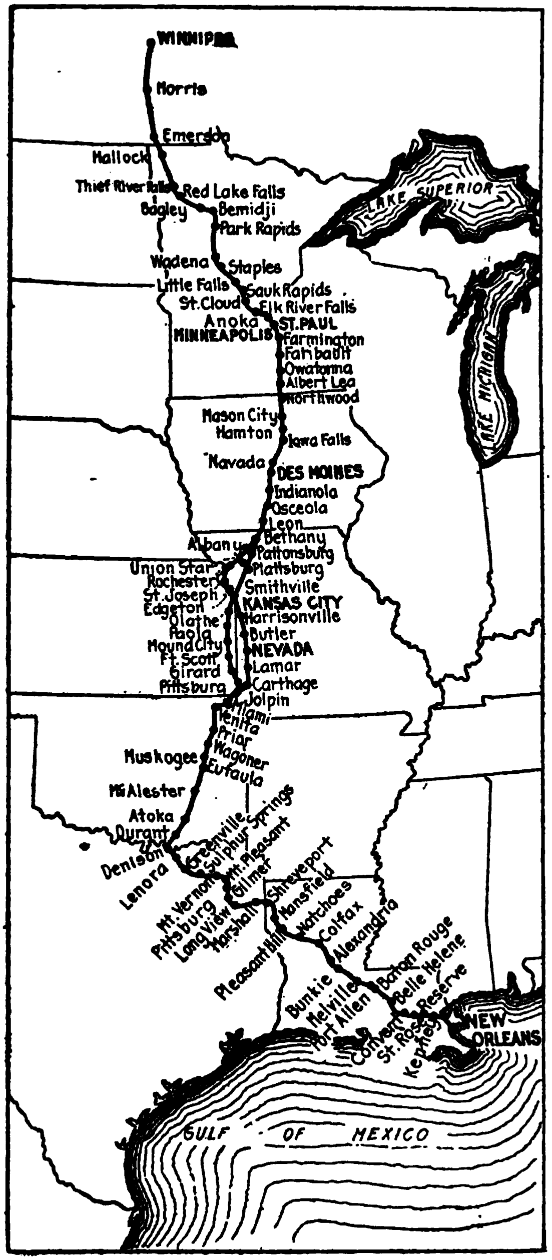
Officers:—President, P. L. Atherton, Louisville, Ky.; vice-president, J. G. Creveling, Jr., Nashville, Tenn.; treasurer, R. R. Elmore, Louisville, Ky.; secretary, M. C. Collier, Louisville, Ky. Indiana officials; vice-president, D. M. Boyle, Lafayette; committee, Walter H. Crim, Salem; W. H. Lincoln, Columbus; W. L. Brown, Frankfort. Kentucky officials; vice-president, Edmund W. Taylor; committee, John G. Kramer, Lexington; Emory G. Dent, Scottsville; L. B. Samuels, Bardstown. Tennessee officials; vice-president, Ben Childers, Pulaski; committee, Judge J. C. Higgins, Fayetteville; J. J. Gray, Jr., Mt. Pleasant; W. S. Schamberger, Gallatin. Alabama officials; vice-president, R. E. Spragins, Huntsville; committee, L. C. Irvine, Mobile; W. T Sanders, Athens; R. T. Simpson, Florence. Mississippi officials; vice-president, J. M. McBeath, Meridian; committee, Thomas J. Lock, Jr., Columbus; W. B. Potts, Kosciusko; E. B. Dunton, Pascagoula. Louisiana officials; vice-president, T. C. Campbell, New Orleans; committee, P. M. Milner, New Orleans; C. H. Ellis, New Orleans; Harry T. Howard, New Orleans.

The final location of the southern part of the Jackson Highway was not settled until November, 1916. The main route shown in the map was then adopted, but an alternative route was taken under advisement. This runs from Nashville through Shelbyville, Fayetteville, Huntsville and Birmingham to Montgomery, and was advocated as desirable for tourists to Florida.



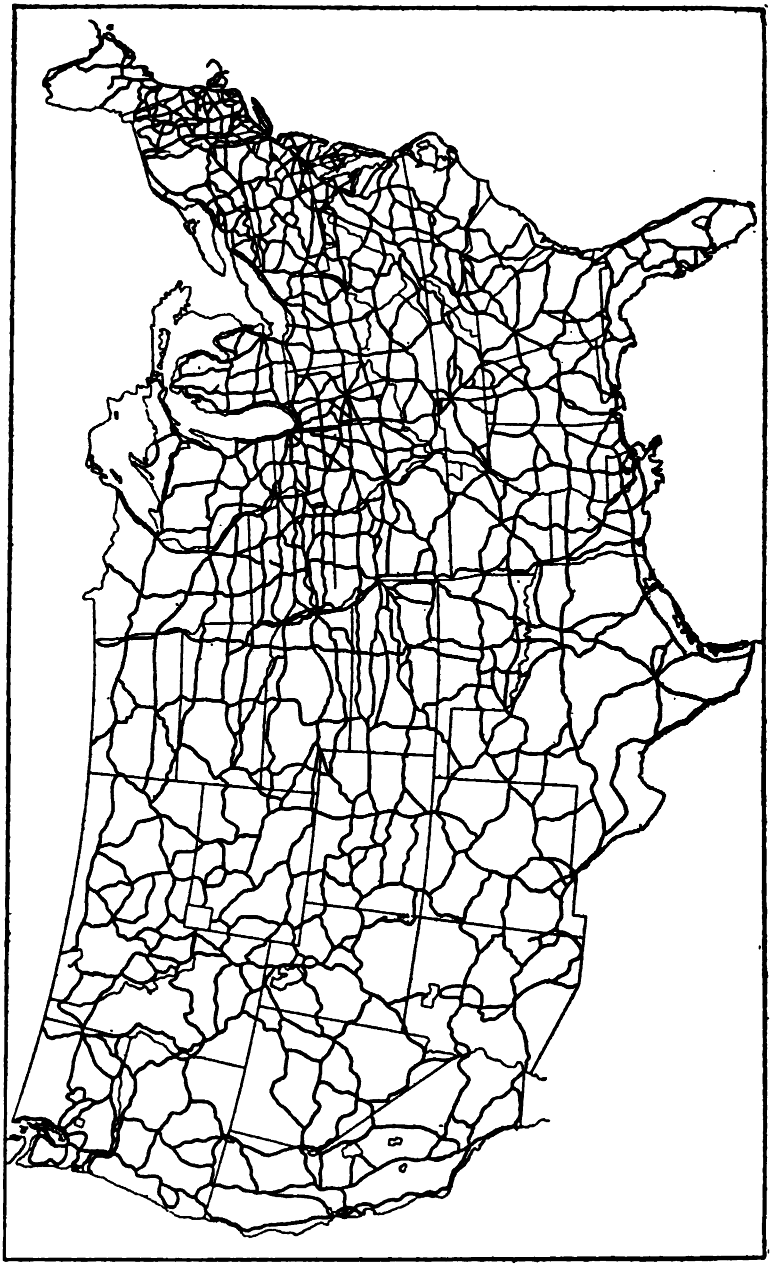
JACKSON HIGHWAY

Jefferson Highway Association



JEFFERSON HIGHWAY

Officers: President, D. N. Fink, Muskogee, Okla.; vice-president, W. A. Hopkins, Lamoni, Iowa; secretary, Walter Parker, New Orleans, La.; treasurer, F. J. Wright, Des Moines, Iowa; general manager, J. D. Clarkson, Des Moines, Iowa. State vice-presidents: Louisiana, P. M. Milner, New Orleans; Texas, W. N. King, Denison; Oklahoma, Dr. Oliver Bagby, Vinita; Kansas, R. S. Tiernan, Ft. Scott; Missouri, John M. Malang, Joplin; Iowa, H. H. Polk, Des Moines; Minnesota, J. H. Beek, St. Paul.



Connecting Highway Systems Advocated by the National Highways Association

National Highways Association

Officers.—Chairman Board of National Councillors, Gen. Coleman du Pont, Wilmington, Del.; president, Charles Henry Davis, C. E., Cambridge, Mass.; vice-presidents, Dr. Lucien Peters McCalla, Boise, Idaho, Elias Vander Horst, New York, Judge J. M. Lowe, Kansas City, Mo., A. L. Westgard, New York, Henry Bronson Varner, Lexington, N. C., and Dr. Joseph Hyde Pratt, Chapel Hill, N. C; general secretary, Dr. Frederic Remsen Hutton, New York; consulting engineer, Prof. Arthur H. Blanchard, New York; assistant director-generals, Walter A. Alsdorf and Z. D. Dunlop, Columbus, O. Offices, 18 Old Slip, New York, N. Y.

This association was organized in 1911 and chartered in 1912, its purpose, as stated in its charter, being "to promote the establishment, building and maintenance of national and other highways throughout the United States." The founder, President Davis, holds that only by the construction and maintenance by the national government of a comprehensive system of national highways serving the total population of the country as a whole, will the great road questions ever be rightly answered; and furthermore, that only by the creation of a national highways commission to study and decide upon the course of action to be taken by the national government will the financial and economic problems involved in such a vast undertaking be properly solved.

The association has spent large sums in compiling data concerning the roads in the different States and in studying their relative importance as main routes of travel. This study has resulted in the selection of the routes shown in outline in the accompanying map as those which are most deserving of improvement as national highways. Field representatives have been employed by the association to stimulate local interest in the betterment of these roads, and the association coöperates with other organizations in this work. The system at first proposed had a total length of about 50,000 miles and served counties with 88 per cent of the urban population of the country and 53 per cent of the rural population. The system was enlarged later to include about 100,000 miles of road as shown on the map. The association publishes maps of the roads in many of the States and also of several of the transcontinental routes with which it is in accord.

The Midland Trail

This starts at Washington, D. C., and Richmond, Va., the two terminal branches to these places joining at Charlottesville, Va. The route passes through Staunton and Lexington, Va.; Charleston and Huntington, W. Va.; Lexington, Frankfort and

Louisville, Ky.; New Albany, Washington and Vincennes, Ind.; Olney, Salem and East St. Louis, Ill.; St. Louis, Union, Koenig, Jefferson City, Sedalia and Warrensburg, Mo.; Kansas City, Topeka, Manhattan, Beloit, Hoxie and Goodland, Kan.; Burlington, Limon, where several alternative routes through Colorado are followed to Grand Junction; Thompsons, Price, Provo, Salt Lake City, Iosepa, Kearney's Ranch and Ibapah, Utah; Tippett, Ely, Currant, Clifford, Hannapah, Tonapah and Goldfield, Nevada; Oasis, Alvord, where alternative routes run through California to Oakland and Los Angeles.

The Midland Trail has a length of 2930 miles from Washington to Oakland and traverses 125 counties in 12 States.

The International Pavedway

This starts at Detroit, Mich. There are two alternative routes to Lafayette, Ind., one through Jackson and Kalamazoo, Mich., and South Bend, Ind., and the other through Toledo, Ohio and Fort Wayne and Marion, Ind. From Lafayette the route is through Danville, Decatur and Springfield, Ill., and St. Louis, Mo. There are two alternative routes from St. Louis, one through Hillsboro, Fredericktown and Greenville and the other through Ste. Genevieve, Perryville and Jackson, to Poplar Bluffs, Mo. Thence the route is through Doniphan, Mo.; Pocahontas, Walnut Ridge, Newport, Searcy, Little Rock, Malvern and Texarkana, Ark.; Clarksville, Paris, Sherman, Dallas, Fort Worth, Cleburne, Walnut Spring, Waco, Austin, San Antonio and Laredo, Tex.

The International Pavedway is 1960 miles long and traverses 88 counties in 7 States.

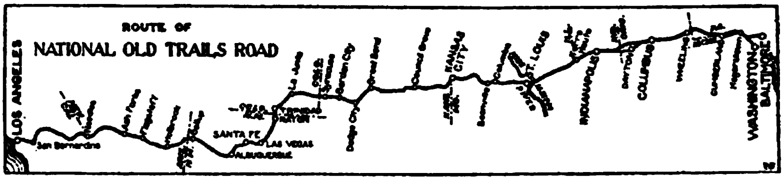
Jefferson Davis Memorial Highway

This route starts at Miami, Fla., and runs through Marco, Fort Myers, Arcadia, Bradentown, Tampa, Tarpon Springs, Brooksville, Ocala, Gainesville, Lake City, Tallahassee and Milligan, Fla., whence alternative routes run to Mobile, Ala. Thence the route is through Gulfport, Miss.; New Orleans, Morgan City, New Iberia, La Fayette and Lake Charles, La.; Beaumont, Liberty, Houston, Victoria, Tex., where two routes begin, one down the coast to Brownsville and then along the border through Laredo and Eagle Pass to Del Rio, and the other through San Antonio to Del Rio. From Del Rio there are two routes to Alfalfa Station, Tex., one along the border and the other through Ozona, Fort Stockton and Marfa. From Alfalfa Station the route is through Aden, Deming and Lordsburg, N. Mex.; Apache, Douglas, Bisbee, Tombstone, Tucson, Phoenix, Agua Caliente and Yuma, Ariz.; and Mammoth, El Centro, Campo and San Diego to Los Angeles, Cal.

The Jefferson Davis Memorial Highway is 3,780 miles long and traverses 94 counties in 9 States. Several of its sections have special names, as follows: Borderland Trail, Los Angeles to El Paso; Border Military Highway, El Paso to Brownsville; Gulf Coast Highway, Brownsville to New Orleans; Old Spanish Trail, New Orleans to Tampa.

Pike's Peak Ocean to Ocean Highway

This route is from New York through Pittsburgh, Columbus, Indianapolis, St. Joseph, Colorado Springs, Salt Lake City and Reno to San Francisco. The details of the route are still undecided in some sections. The president of the route is C. F. Adams, of Chillicothe, and the secretary and treasurer is A. W. Henderson, of Colorado Springs, Colo.



National Old Trails

This route is from Washington through Wheeling, Indianapolis, St. Louis, Kansas City, Trinidad and Albuquerque to Los Angeles.

This route follows the Cumberland or National road, Boone's Lick road, the Santa Fe trail and General Kearney's trail. The president of the association is Judge J. M. Lowe, of Kansas City, Mo.

Santa Fe Trail

This route is also known as the Trail to the Sunset. It runs from New York through Chicago, Kansas City, Trinidad, Phoenix and Yuma to San Diego.

Southern National Highway

This route runs from Washington through Richmond, Durham, Nashville, Memphis, Little Rock, Dallas, Fort Worth, Roswell, El Paso, Phoenix and Yuma to San Diego.

Atlantic Highway

This route runs from Calais through Boston, New York, Washington, Richmond, Raleigh, Rockingham, Camden, Columbia, Augusta, Savannah, Jacksonville, Miami. A considerable part of this route is practically the same as the Capital Highway, which is in a better general condition than any other national highway route, owing to the persistent work during many years of Leonard Tufts, of Pinehurst, N. C., president of the Capital Highway Association.

Meridian Road

This route runs from Pembina, Man, through Fargo, Columbus, Wichita, Fort Worth and Houston to Galveston.

Pacific Highway

This route is 1662 miles long. It runs from Vancouver, B. C., through Seattle, Tacoma, Portland, Eugene, Grants Pass, San Francisco, Los Angeles and San Diego to Tia Juana, Mex. Alternative routes exist along parts of it.

The Ozark Trail

This is promoted by one of the most active associations in the country, of which the president is W. H. Harvey, of Monte Ne, Ark, and the secretary is Charles W. Fear, of Joplin, Mo. It has already marked about 1000 miles of road, and has been particularly active in urging that road work be placed under competent men and that the first improvements be relocation, grading, drainage and low-cost surfacing. The route runs from St. Louis through Springfield, Mo., Tulsa, and Oklahoma City, Okla., Amarillo, Tex., to Albuquerqe, N. Mex. Between these main points a number of alternative routes have been projected and some of them have been marked.

NATIONAL ASSOCIATIONS

Permanent International Association of Road Congresses

Officer.—M. Mahieu, secretary-general, 1 Avenue d'Iena, Paris, France.

1. OBJECT AND ORGANIZATION OF THE ASSOCIATION

ARTICLE I

The object of the Permanent International Association of Road Congresses is to promote progress in the construction, traffic and exploitation of roads.

It continues the work of the first International Road Congress held in Paris in October, 1908.

It accomplishes its object: 1, By organising Road Congresses; 2, by publishing papers, proceedings, and other documents; 3, by collecting the results of (*a*) tests carried out on roads; (*b*) laboratory tests throughout the world on materials which are used or are suitable for road construction and maintenance; these tests may be either in the form of mere records collected by the Association or they may have been carried out by the Association itself or through its instrumentality.

Its affairs are managed by a Permanent International Commission.

ARTICLE II

The Association consists of:

1. Delegates of Governments and Corporations of all the countries which subscribe annually to the Association.

2. Private Members.

Membership may be either permanent or temporary.

Governments may appoint one official delegate, with a right to vote at every Congress, for each 250 francs of their annual subsidy.

This amount is reduced to 100 francs for Corporations.

Permanent Members are entitled to attend and vote at every Congress.

Temporary members are entitled to attend the particular Congress they have joined, and they may vote on all questions which do not affect the Permanent Association itself.

3. Honorary Members, nominated by the Permanent International Commission.

ARTICLE III

1. A Permanent International Commission, with headquarters at Paris, is at the head of the Association.

2. A Permanent Council and an Executive Committee are appointed from amongst the Members of this Commission.

ARTICLE IV

The Permanent International Commission is composed of members belonging to the various countries represented in the Association. Each country has the right to one representative for each 1000 francs of its total annual subsidy.

Provided, however, that the number of representatives from any one country shall not exceed 15 (fifteen), and that any country which pays not less than 250 francs shall have the right to appoint one delegate.[1]

American Highway Association

The American Highway Association was organized at Washington, D. C., November 22, 1910.

Its purposes are:

To correlate and harmonize the efforts of all existing organizations working for road improvement.

To arouse and stimulate sentiment for road improvement.

To strive for wise, equitable and uniform road legislation in every State.

To aid in bringing about efficient road administration in the States and their subdivisions, involving the introduction of skilled supervision and the elimination of politics from the management of the public roads.

To seek continuous and systematic maintenance of all roads, the classification of all roads according to traffic requirements, payment of road taxes in cash, and adoption of the principle of State aid and State supervision.

To advocate the correlation of all road construction so that the important roads of each county shall connect with those of the adjoining counties and the important roads of each State shall connect with those of adjoining States.

To strive for the utilization of convict labor on works of public improvement, where that course is consistent with the local policy, so as to involve the least possible competition with free labor, the utmost public benefit, and a healthy moral and physical development of the convict. In many States these results can be attained by using the convicts on road work or the preparation of road materials.

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[1] For further information address either the secretary general or the American Highway Association.

CONSTITUTION

ARTICLE I

Name

SECTION 1. The name of this organization shall be THE AMERICAN HIGHWAY ASSOCIATION.

ARTICLE II

Object

SECTION 1. The object of this Association is to harmonize and correlate all efforts for the improvement of the public roads, to the end that adequate and efficient systems of road construction, administration, and maintenance may be adopted in all of the States.

ARTICLE III

Location

SECTION 1. The official headquarters of this Association shall be located and maintained in the city of Washington, D C.

ARTICLE IV

Membership

SECTION 1. The regular membership of this Association shall be composed of all persons who shall sign the roll of membership at the time of organization, or make written application to the Secretary and pay annual dues for one year in advance, membership to begin with written acceptance by the Secretary.

SEC. 2. The associate membership shall consist of all members of State and other organizations for road improvement, coöperating with this Association, *provided*, that a roster of such membership shall be filed with the Secretary by said organization.

SEC. 3. The sustaining membership shall consist of all persons or organizations who shall sign the roll of sustaining membership at the organization of this Association, or make written application to the Secretary and pay annual dues for sustaining membership one year in advance, membership to begin as soon as written acceptance shall have been received from the Secretary.

ARTICLE V

Officers

SECTION 1. The officers of this Association shall consist of a President, a Vice-President, a Treasurer, and a Board of Directors, consisting of the President and Vice-President of the Association and twenty-three additional members, to be elected at the annual meeting of the Association as hereinafter provided, and such other executive officers as may be appointed by the Executive Committee.

SEC. 2. The President, Vice-President, Treasurer, and members of the Board of Directors shall be regular or sustaining members of the Association, and shall be elected at the first regular meeting and annually thereafter, except that the members of the Board, exclusive of the officers, shall be elected in three groups, the first to hold office for a period of three years, the second to hold office for a period of two years, and the third to hold office for a period of one year, vacancies on the Board to be filled annually thereafter.

ARTICLE VI

Committees

SECTION 1. There shall be four standing committees of this Association: An Executive Committee, consisting of five members; a Finance Committee; a Committee on Membership, and an Auditing Committee, consisting of three members. The members of the Auditing Committee shall be selected by the President at the first annual meeting, and shall hold office until the next regular meeting of the Association. The members of the other three committees shall be selected by the Board of Directors, and shall hold office until the next regular meeting of the Association.

ARTICLE VII

Amendments

SECTION 1. This Constitution may be amended at any regular meeting of the Association by three-fourths of the qualified voters present, *provided*, that the Secretary shall notify members of the Association of said regular meeting.

ARTICLE VIII

By-Laws

SECTION 1. The Board of Directors shall make such By-Laws for the government of the Association as it may deem necessary, and which shall not conflict with the provisions of the Constitution, and may amend or alter the same.

By-Laws

ARTICLE I

Annual Dues

SECTION 1. The annual dues for regular members of the Association shall be $5, payable in advance. Annual dues for sustaining members shall be $100, payable in advance. Associate members shall not be required to pay annual dues to this Association.

ARTICLE II

Voting Privileges

SECTION 1. Regular members of the Association shall be entitled to participate in its proceedings, and vote upon all questions that may come before the Association. Associate members shall be entitled to participate in discussions of questions before the Association. Sustaining members shall be entitled to participate in discussions, and to vote upon questions before the Association.

ARTICLE III

Duties of Officers

SECTION 1. The President shall be the executive head of the Association He shall preside at all meetings of the Association, and shall appoint an Auditing Committee and all temporary committees.

SEC. 2. In the absence of the President the Vice-President shall act in his place and stead, *provided*, that in the absence of both the President and Vice-President the Executive Committee shall immediately elect one of its members to perform the duties of the President.

SEC. 3. The Secretary shall keep the records and minutes of the Association. He shall draw all orders upon the Treasurer for the payment of money. He shall serve all notices and perform all duties necessary to the proper conduct of the business affairs of the Association, and shall perform such additional duties as may be assigned to him by the Board of Directors. He shall make written report annually of the work of the Association, and shall make such special written reports to the Board of Directors as they may require from time to time.

SEC. 4. The Treasurer shall be the custodian of the funds of the Association. He shall pay all orders for money duly signed by the Secretary. He shall make a written report annually to the Association, accounting for all funds received and disbursed. If the Treasurer shall for good and sufficient reason be temporarily unable at any time to perform the duties of his office, he shall so inform the chairman of the Executive Committee, who shall, with the concurrence of two other members of said committee, designate one of their members to perform the duties of Treasurer, until such time as the Treasurer shall resume his duties and so inform the chairman of the Executive Committee.

SEC. 5. The Organizer shall perform such duties as are assigned to him by the Board of Directors.

SEC. 6. The Board of Directors shall at its first meeting and annually thereafter elect a chairman. The Board shall have custody of all property of the Association; shall have charge of the financial affairs of the Association; shall provide ways and means for its expenses, shall appoint all regular committees and all officers not otherwise provided for, shall have supervision and control over all work carried on by the Association and its officers, and shall fill all vacancies in its own membership and among the officers of the Association between the meetings of the Association.

ARTICLE IV

Duties of Committees

SECTION 1. The Executive Committee shall act for the Board of Directors and exercise all the powers of said Board in the interim between the meetings of said Board, and shall report quarterly to the Board the condition of the Association and its work.

SEC. 2. The Committee on Finance shall provide for the raising of funds to carry on the work of the Association and shall have supervision over the financial affairs of the Association.

SEC. 3. The Committee on Membership shall deal with all questions relating to membership in the Association, and shall take such steps as it may deem advisable for increasing the membership of the Association.

SEC. 4. The Auditing Committee shall audit and review the reports of the Secretary and the Treasurer.

ARTICLE V

Meetings

SECTION 1. Regular meetings of the Association shall be held annually at such time and place as the Board of Directors may determine. Special meetings may be called by the Board of Directors, or by two-thirds of the regular members of the Association.

SEC. 2. The Board of Directors may fix the time and place of its meetings, provided that it shall meet at least once in each year.

SEC. 3. The Executive Committee shall fix the time and place of its meeting, provided that it shall meet at least once in each three months.

ARTICLE VI

Quorums

SECTION 1. A quorum of the Association shall consist of fifty members who shall be present in person.

SEC. 2. A quorum of the Board of Directors shall consist of five members who shall be present in person.

SEC. 3. A quorum of the Executive Committee shall consist of a majority of its members.

ARTICLE VII

Amendments

SECTION. 1. The By-Laws of this Association may be altered or amended by the Board of Directors, at their discretion, *provided*, that such By-Laws shall not conflict with the provisions of the Constitution.

Fairfax Harrison, president; Logan Waller Page, vice-president; John Burke, treasurer; Leonard Tufts, chairman executive committee; Frank A. Vanderlip, chairman committee on membership; J. C. Hemphill, chairman committee on publicity; directors, James S. Harlan, chairman; Charles Whiting Baker, A. G. Batchelder, W. T. Beatty, Charles D. Blaney, S. E. Bradt, R. D. Chapin, George W. Cooley, Richard H. Edmunds, Austin B. Fletcher, Fairfax Harrison, A. N. Johnson, L. E. Johnson, Joseph W. Jones, Clarence A. Kenyon, E. J. Mehren, James H. MacDonald, Thomas G. Norris, Logan Waller Page, Joseph Hyde Pratt, Henry G. Shirley, Leonard Tufts, W. Tom Winn. Offices, Colorado Building, 1341 G Street N. W., Washington, D. C.

PUBLICATIONS

Good Roads Year Book, 1912, 1913, 1914, 1915, 1916 and 1917.

Proceedings of First American Road Congress, $1.00. (Held in Richmond, Virginia, November 20–23, 1911.)

Proceedings of Second American Road Congress, $1.00. (Held in Atlantic City, N. J., September 30–October 5, 1912.)

Proceedings of the Third American Road Congress, $1.00. (Held in Detroit, Michigan, September 29-October 4, 1913.)

Proceedings of the Fourth American Road Congress, $1.00. (Held in Atlanta, Georgia, November 9–14, 1914.)

Proceedings of the Pan-American Road Congress, $1.00. (Held in Oakland, California, September 13–17, 1915.)

Bulletin 1. The relation of the contractor to the public official. C. A. Crane, secretary, The General Contractors' Association.

Bulletin 2. Modern methods of road surface preservation by bituminous preparations. Chas. W. Ross, superintendent of streets, Newton, Mass.

Bulletin 3. Bond issues for road improvement. Hon. Lee McClung, treasurer of the United States.

Bulletin 4. Good roads and the cost of living. W. W. Finley, president, Southern Railway Company.

Bulletin 5. Earth, sand-clay and similar materials, qualities and methods of application. W. S. Keller, State highway engineer of Alabama.

Bulletin 6. Street pavements: their selection, care and maintenance. By Geo. W. Tillson, consulting engineer to the borough president, Borough of Brooklyn, New York City.

Bulletin 7. Road administration. By Col. W. D. Sohier, chairman of the Massachusetts State Highway Commission.

Bulletin 8. The labor problem in road construction. By P. St. J. Wilson, State highway commissioner of Virginia.

Bulletin 9. Bond issues for road improvement. By S. E. Bradt, member Illinois State highway department.

Bulletin 10. Systematizing the purchase of road materials and equipment. By Henry G. Shirley, chief engineer, State roads commission of Maryland.

Bulletin 11. Highway accounting, with special reference to maintenance. By Halbert P. Gillette, M. Am. Soc. C. E., chief editor of "Engineering and Contracting."

Bulletin 12. Unsurfaced roads. By W. S. Keller, State highway engineer of Alabama.

Bulletin 13. The protection and upkeep of road equipment. By Daniel J. Hauer, construction economist and consulting engineer.

Bulletin 14. Waterway structures. By A. R. Hirst, State highway engineer of Wisconsin.

Bulletin 15. Legal suggestions respecting road contracts. By William Law Bowman, C. E., LL. B., New York Bar.

Bulletin 16. Treatment of worn out and ravelled macadam surfaces. Address of Col. E. A. Stevens, State highway commissioner of New Jersey.

Bulletin 17. The selection of materials for macadam roads. By Logan Waller Page, director U. S. Office of Public Roads.

Bulletin 18. Concrete roads. By Hon. Frank F. Rogers, State highway commissioner of Michigan.

Bulletin 19. Bituminous construction. By S. D. Foster, chief engineer Pennsylvania State highway commission.

Bulletin 20. Educational field for highway departments.
By Dr. Joseph Hyde Pratt, State geologist of North Carolina.

Bulletin 21. Engineering supervision of road construction.
By W. S. Keller, State highway engineer of Alabama.

Bulletin 22. Road economics. By J. E. Pennybacker, chief of road economics, U. S. Office of Public Roads.

Bulletin 23. State control of road work as a policy.
By A. N. Johnson, chief engineer, bureau of municipal research, New York City.

Bulletin 24. Rights of way.
By Austin B. Fletcher, State highway engineer of California.

Bulletin 25. Drainage structures.
By W. E. Atkinson, State highway engineer of Louisiana.

Bulletin 26. Grades and excavation.
By A. D. Williams, chief engineer State roads commission of West Virginia.

Bulletin 27. Light traffic roads.
By S. Percy Hooker, State superintendent of highways of New Hampshire.

Bulletin 28. Selecting the roads to be improved.
By Fairfax Harrison, president, Southern Railway Company.

Bulletin 29. Heavy traffic roads.
By Henry G. Shirley, chief engineer, State roads commission of Maryland.

Bulletin 30. Maintenance of earth roads.
By George W. Cooley, State highway engineer of Minnesota.

Bulletin 31. Maintenance of surfaced roads.
By Col. William D. Sohier, chairman, Massachusetts highway commission.
Bulletin 32. System in road management.
By Charles J. Bennett, State highway commissioner of Connecticut.
Bulletin 33. Bituminous macadam by the cold mixing method.
By Irving W. Patterson, chief engineer, Rhode Island State board of public roads.
Bulletin 34. Convict labor.
By George P. Coleman, State highway commissioner of Virginia.

Note.—All publications are sent free to members of the association. The annual dues for membership are $5.00, and cover a period of twelve months from date of payment. Remittance for either dues or publications should be made to John Burke, treasurer.

American Association of State Highway Officials

The purpose of this organization is to study the various materials for, and methods of construction and maintenance of, the roads of the United States; to exchange information and promote closer relations between State highway departments, with a view to establishing more uniform systems of legislation, administration, construction and maintenance respecting roads, so as to increase efficiency in the work and conserve the capital invested in highways; to coöperate in every possible way with the office of Public Roads and Rural Engineering and similar federal bureaus in the consideration of road problems.

Active membership is limited to State highway commissioners, chief engineers and other chief directing officials actively engaged in the administrative work of State highway departments or the United States government. Associate members are such assistant and deputy commissioners, assistant and resident engineers, and chief directing officials in the highway departments of other North American countries, as are proposed by active members.

Honorary members are former active members who cease to be eligible for the latter rank, and the professors of highway engineering in accredited universities. The annual dues are $5 for active members, $3 for associate members, and $25 commutation fee for all active members in the highway department of any State.

The officers are selected from the active members and no State can be represented by more than one officer. There are four special standing committees, executive, finance, tests and investigations, and standards. The committee on tests and investigations is instructed to confer with highway departments and similar committees of other organizations respecting tests and investigations of the value of different road materials. The committee on standards is instructed to coöperate with State and United States departments and other organizations in establishing standard types of construction and standard systems of maintenance.

Officers.—President, George P. Coleman, Highway Commissioner of Virginia, Richmond; vice-president, A. B. Fletcher, State Highway Engineer of California, Sacramento; secretary, Dr. Joseph Hyde Pratt, State Geologist of North Carolina, Chapel Hill; treasurer, F. F. Rogers, State Highway Commissioner of Michigan, Lansing; executive committee, W. D. Uhler, Chief Engineer, State Highway Department of Pennsylvania, Harrisburg; Lamar Cobb, State Engineer of Arizona, Phoenix; T. H. MacDonald, State Highway Engineer of Iowa, Ames; Col. E. A. Stevens, State Road Commissioner of New Jersey, Trenton; Henry G. Shirley, Chief Engineer, State Roads Commission, Baltimore.

American Automobile Association

Officers.—Dr. H. M. Rowe, president, Baltimore, Md.; George C. Diehl, chairman good roads board, 575 Ellicott Square, Buffalo, N. Y.; A. G. Batchelder, chairman executive board, Riggs Building, Washington, D. C.

National Capital Headquarters.—Riggs Building, Washington, D. C.

New York City Headquarters.—437 Fifth Avenue, New York.

American Concrete Institute

Officers.—William K. Hatt, Professor of Civil Engineering, Purdue University, Lafayette, Indiana, president; Henry C. Turner, President Turner Construction Company, 11 Broadway, New York City, vice-president; Robert W. Lesley, Pennsylvania Building, Philadelphia, Pennsylvania, treasurer; H. D. Hynds, Atlas Portland Cement Company, 30 Broad Street, New York, secretary.

American Road Builders' Association

Officers.—Arthur W. Dean, president, Boston, Mass.; E. L. Powers, secretary, New York; W. W. Crosby, treasurer, Baltimore, Maryland.

Headquarters.—150 Nassau Street, New York.

American Society for Testing Materials

Officers.—A. A. Stevenson, Philadelphia, Pa., president; Edgar Marburg, University of Pennsylvania, Philadelphia, secretary-treasurer.

American Society of Civil Engineers

Officers.—Geo. H. Pegram, president; Charles Warren Hunt, secretary.

Headquarters.—220 West 57th Street, New York.

Purposes so far as they relate to roads.—Investigation and discussion of technical problems of road construction and maintenance.

American Society of Engineering Contractors

Officers.—President, Wm. P. Carmichael; first vice-president, John J. English; second vice-president, O. Lefebvre; secretary, J. R. Wemlinger, 44 Whitehall Street, New York; treasurer, G. A. Unverzagt.

Association of American Portland Cement Manufacturers

Officers.—President, B. F. Affleck, president Universal Portland Cement Co.; vice-presidents, F. W. Kelley, president Helderberg Portland Cement Co., and Richard Hardy, president Dixie Portland Cement Co.; treasurer, G. S. Brown, president Alpha Portland Cement Co.; general manager, J. P. Beck.

Headquarters.—111 West Washington Street, Chicago, Ill.

Objects.—To acquire and disseminate information concerning the best practice in the use of cement and concrete.

To raise the standards of construction.

To emphasize the necessity of careful attention to all details of construction and to the selection of such materials as will produce the best results.

To give to anyone requesting same, information they may desire on the proper use of cement and concrete.

Canadian Highway Association

Officers.—Hon. Thomas Taylor, Minister of Public Works, B. C., honorary president; W. J. Kerr, president, New Westminister, B. C., Frank E. Mutton Toronto, Ontario, vice-president; P. W. Luce, New Westminister, B. C., secretary; T. S. Baxter, Vancouver, B. C., treasurer.

Purpose.—This organization is not actively concerned with the actual construction and improvement of roads, but work, is mainly along educational lines.

Canadian Society of Civil Engineers

Officers.—G. H. Duggan, Montreal, president; R. A. Ross, Montreal, A. St. Laurent, Ottawa; T. H. White, Vancouver, vice-presidents; E. Marceau, Montreal, treasurer; C. H. McLeod, Montreal, secretary.

Committee on Roads and Pavements.—W. A. McLean, Department of Public Highways, Parliament Buildings, Toronto, Ontario, Chairman.

Dominion Good Roads Association

Officers.—J. Duchastel de Montrouge, Outremont, P. Q., president; Geo. A. McNamee, New Birks Building, Montreal, secretary.

National Association of Sand and Gravel Producers

Officers.—F. W. Renwick, Chicago Gravel Company, 343 S. Dearborn Street, Chicago, Illinois, president; H. M. Halliday, Halliday Sand Company, Cairo, Illinois, first vice-president; W. F. Bradley, Ohio and Michigan Sand and Gravel Company, Toledo, Ohio, second vice-president; H. F. Curtis, Lyman Sand Company, Omaha, Nebraska, third vice-president; Lee R. Witty, Wabash Sand and Gravel Company, Terre Haute, Indiana, fourth vice-president.

National Automobile Chamber of Commerce

Officers.—President, Charles Clifton; vice-president, Wilfred C. Leland; second vice-president, gasoline division, Hugh Chalmers; second vice-president, commercial vehicle division, Windsor T. White; second vice-president, electric vehicle division, H. H. Rice; secretary, R. D. Chapin; treasurer, George Pope; general manager, Alfred Reeves, 7 East 42d Street, New York.

National Conference on Concrete Road Building

Officers.—W. F. M. Goss, chairman; J. P. Beck, secretary, 111 West Washington Street, Chicago, Ill.

National Paving Brick Manufacturers Association

Officers.—C. C. Blair, president, Youngstown, Ohio; J. W. Robb, vice-president, Clinton, Indiana; C. C. Barr, treasurer, Streator, Illinois; Will P. Blair, secretary, Cleveland, Ohio; H. H. MacDonald, assistant secretary, Cleveland, Ohio. Executive Board, C. C. Blair, Charles J. Deckman and J. G. Barbour.

Purposes.—The National Paving Brick Manufacturers Association of this country was organized for the following purposes:

1. A dissemination among its membership of technical knowledge relating to the manufacture of their product.
2. To bring to the attention of the public the merits of Vitrified Brick as a paving material.
3. To influence to the greatest possible extent the proper construction of brick streets.
4. For furnishing truthful and reliable information regarding other paving materials, and their comparative value as pavements when considered with brick pavements.

Northwestern Road Congress

Officers.—A. D. Gash, Springfield, Ill., president; T. R. Agg, Ames, Iowa, secretary-treasurer.

United States Good Roads Association

Officers.—Senator John H. Bankhead, president; J. A. Rountree, Brown Marx Building, Birmingham, Ala., secretary.

NAMES AND ADDRESSES OF CONTRACTORS REPORTED AS BIDDING ON HIGHWAY WORK DURING 1916[1]

Alabama

Alabama Paving Co., Birmingham.
Allen, W. F., Montgomery
Brown, J. G., Montgomery
Central Alabama Construction Co., Thomasville
Collins, J. M., Eclectic
Cook & Co., D. R., Selma
Dunn & Deland, Birmingham
Dunn Construction Co., Birmingham
Edgar, C. J., Vernon
Ensley Construction Co., Ensley
Gadsden Concrete Co., Gadsden
Giddens, J. F. & Co., Grady
Goodrich & Crinkley, Anniston
Hallowell, Wm. D., 50 Morgan Ave., Montgomery
Hancock, Hardin & Hancock, Mobile
Hicks & Son, W. A., Seale
Jett Brothers, Mobile
Jett-Muth Construction Co., Mobile
Kershaw, C. G. Gadsden
Keyser, J. K., Burnt Corn
Maxwell, Max T., Tuscaloosa
Maynord, E R., Ensley
Meade & Co., Ensley
Morgan & Co., J. F. Gadsden
Mullarky, J. L., Cullman
Newell Bros. Construction Co., Birmingham
Nixon-Smith Construction Co., Thomaston
O'Brien Construction Co., Eutaw
O'Brien, P. H., Birmingham
Pearson, L. C., Guntersville
Pepperman, B. A., Birmingham
Perry, A. E., Montgomery
Richter, Paul, Birmingham
Rowlinson & Thomas, Monroeville
Southern Bitulithic Co., Birmingham
Shuptrine, C. E., Central Mills
Stanley & Singer Construction Co., Lafayette
Wade, B. P. ,Trussville
Wade, Perry, Ashville
Wofford & Brown, Dothan
Woolfolk, Robert, Montgomery
Worthington Construction Co., The, Birmingham
Wright, Jr., J. W., Brewton

Arizona

Aubrey Construction Co., Prescott
California-Arizona Construction Co., Phoenix
Mullen, Wm. J., Flagstaff
Pacheco, J., Tucson

Arkansas

Argo & Young, Batesville
Bell, W. B., Van Buren
Burke Construction Co., Fort Smith
Cole, Jr., M. J., Little Rock
Connelly Paving Co., P. F., Little Rock
Cook, M. D. L., Little Rock
Elleffson, A., Fort Smith
Jackson, W. C., Russellville
McEtchin & McEtchin, Little Rock
Mobley, H. R., Argenta
Peay Construction Co., Nick, Little Rock
Perdue & Co., J. A., Pine Bluff
Pettit-Galloway Co., Little Rock
Philpot, C. M., Pine Bluff
Royce, E. C., Pine Bluff
Shelby & Bateman, Little Rock
Shelby & Co., I. P., Little Rock
Smith, A. B., Pine Bluff

California

Atkinson, Lynn S., Investment Bldg., Los Angeles
Baker, E. A., 407 H. W. Hellman Bldg., Los Angeles
Bayard & Austin, 1650 Compton Ave., Los Angeles
Bayles, Daniel, Biggs
Beatty & Gates, Vacaville
Benson & Sons, Geo. S., Los Angeles
Bent Bros., 825 Central Bldg., Los Angeles
Bienfield, D. L., Phelan Bldg., San Francisco
Blanchard-Brown Co., San Francisco
Bohan, W. D., San Bernardino
Brashear-Burns Co., Van Nuys Bldg., Los Angeles
Breitenstein, Thomas C., 405 Douglas St., Pasadena
Brent Bros., 825 Central Bldg., Los Angeles
Brownlee, S. P., San Rafael
Bryant & Sonnickson, Palo Alto
Burns, Clark & Royce, Sacramento
Burns, E. A., 335 N. San Joaquin, Stockton
California-Arizona Construction Co., 1700 E. Washington St., Los Angeles
California Road & Street Improvement Co., Fresno
Castro & Blaisdell, Bakersfield
Central California Paving Co., Modesto
Chadwick & Sykes, Crocker Bldg., San Francisco
Church Co., D. O., 57 Port St., San Francisco
City Street Improvement Co., San Francisco

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[1] The accuracy of these names has been partially tested by the rejection from the list of all names of contractors who were reported as "not found" by the U. S. Post Office Department.

Clark & Henry Construction Co., Sacramento
Clark & Henry Construction Co., Stockton
Coast Construction Co., 353 South Hill St., Los Angeles
Conner Contracting Co., 709 Higgins Bldg., Los Angeles
Conner Contracting Co., Hemet
Cornell & Henderson, Glendale
Cornwall, J. T., Santa Barbara
Cox, H. E., Chamber of Commerce Bldg., Pasadena
Crites, B., 129 S. Rio St., Los Angeles
Curtis, Geo. R., 552 S. St. Louis, Los Angeles
Daley, G. R., San Diego
Davidson Contracting Co., B. R., Monrovia
Driskill, J. ,Long Beach
Eaton & Smith, San Francisco
Elsemore & Jacobs, Eureka
Engebretson, John, Coronado
Esterly, W. B., San Francisco
Eureka Paving Co., Eureka
Fairchild-Gilmore Milton Co., Pacific Electric Bldg., Los Angeles
Farish & Co., W. A., 353 S. Hill St., Los Angeles
Federal Construction Co., Monadnock Bldg., San Francisco
Ford, Oscar, Riverside
Ford & Stout, Bradbury Bldg., Los Angeles
Franks, J. H., 639-29th Ave., San Francisco
Frenzel, Ernest, Redlands
Frey, F. E., Sacramento
Garland, E. A., Ventura
Garnsey, Leigh G., Central Bldg., Los Angeles
Gaskell & Foley, Stockton
Gillham & Sons, W. L., San Jose
Goodbody, M. D., San Diego
Greene, W. E., Tulare
Haddock, J. E., 357 N. Chester St., Pasadena
Hall & Hunt, Fresno
Hart & Ducey, Pasadena
Healy-Tibbetts Construction Co., San Francisco
Hein, E. J., 511 Stimson Bldg., Los Angeles
Heinauer & Kyle, Watts
Hewitt & Feloh, Palermo
Highway Construction Co., San Bernardino
Hoare, P. H., Oakland
Hoffman, Fred, 111 East 12th St., Long Beach
Holloway, A., 471 S. Broadway, Pasadena
Howard, P. A. & C. H., 2128 Sacramento St. Los Angeles
Hudson, C. H., 509 Trust & Savings Bldg., Los Angeles
Hyde Construction Co., San Diego
Isbell Construction Co., Corona
Jacinto, Manuel, Sacramento
Johnson & Shea Co., Riverside
Keatings & Son, R., San Francisco
Keep, W. A., Alhambra
Kellogg, H. Clay, Santa Ana
Kettlewell & Sons, W. A., Sanger
Kueen Co., J. D., Dudley Bldg., Santa Monica
Leichert & Son, A., Sacramento
Liddington, Wm., 420 E. 60th St., Los Angeles
Los Angeles Paving Co., Anaheim
Los Angeles Paving Co., 2900 Santa Fe Ave., Los Angeles
Luhrsen, G., Bethany
McAlpin, E. E., San Diego
McCleary, S. W., 121 E. Oak St., Lodi
McCray, A. L., 234 W. 28th St., Los Angeles
McCray Co., R. H., 422 American Bank Bldg., Los Angeles
McCray, S., 469 W. Ave. 52, Los Angeles
McElroy, W. H., Merced
McElwaine, Charles, San Bernardino
McGillivray Construction Co., Nicolaus Bldg., Sacramento
McLean Co., A. C., 320 Market St., San Francisco
McNair, James, San Bernardino
Mackie & McLean, Maricopa
Marin Rock Co., San Anselmo
Marsh, John D., 155 Wilson Bldg., Los Angeles
Marshall, J. A., Berkeley
Mercereau Bridge & Construction Co., Los Angeles
Merrill, R. A., Los Angeles
Mesmer & Rice, Marsh-Strong Bldg., Los Angeles
Metropolitan Construction Co., 155 Wilson Bldg., Los Angeles
Miller, W. E., Santa Cruz
Modern Construction Co., Los Angeles
Morenig, Cy., Stockton
Municipal Improvement Co., Santa Barbara
Nelson, Olaf., San Diego
Oakland Paving Co., 5000 Broadway, Oakland
O'Brien Bros., Martinez
Ockert, F., Santa Monica
Oswold Bros., 455 O. T. Johnson Bldg., Los Angeles
Oxsen & McDonald, Pleasanton
Pacific Cresote Co., San Francisco
Paul & Caldwell, 28 W. Park St., Stockton
Pearson, Anderson & Summers, 219 Lissner Bldg., Los Angeles
Pendola, Louis L., Santa Barbara
Powell Bros. Construction Co., Alameda
Price & Co., W. C., San Francisco
Price, W. E., Martinez
Proctor, W. L., Santa Rosa
Raisch Improvement Co., Crocker Bldg., San Francisco
Ransome-Crummey Co., First National Bank Bldg., Oakland
Ritchie, F. R., San Francisco
Roberts, C. A., 1350 W. Temple St., Los Angeles
Rodger Bros. Co., Hibernian Bldg., Los Angeles
Rogers Bros., Los Angeles
Ross Construction Co., Forum Bldg., Sacramento
Schelling, E., Burbank
Selvage, W. S., Eureka
Shafer, M. T., 220 W. 33rd St., Los Angeles
Shrerer Co., R., 648 Pacific Electric Bldg., Los Angeles
Silva & Woods, Petaluma
Snyder Construction Co., George, Upland
S. C. Contracting Co., Santa Monica
S. C. Construction Co., Washington Bldg. Los Angeles
Southern California Contracting Co., Title Insurance Bldg., Los Angeles
Steffgen, Charles, San Diego
Stone, E. B. & A. L., San Francisco
Street Improvement Co., 166 Geary St., San Francisco
Taylor & Berliner, Box 35, Willow
Teichert & Son, A., Ochsner Bldg., Sacramento
Terry, Peter L., 536 Acacia Ave., Tropico
Thompson Bros., Fresno

Tibbitts-Pacific Co., San Francisco
Tucker Co., Shull, Riverside
Tyron & Brain, 501 Merchants Trust Bldg., Los Angeles
Ulrich & Howell, Modesto
Vornwell, J. T., Santa Barbara
Western Motor Draying Co., 373 Noe St., San Francisco
White & Gaskill, Long Beach
Williams-Belser Co., San Francisco
Williams, Howard S., San Francisco
Worswick Street Paving Co., Fresno

Canada

Brennan & Hollingsworth, Hamilton, Ontario
Bushell, W., Toronto
Chick Contracting Co., McDougall St., Windsor, Ontario
Connor, P. A., Huntingdon, P. Q.
Fallahee, John, Chathan, Ontario
Godson Contracting Co., Manning Chambers, Toronto
Harris, R. C., City Hall, Toronto, Ontario
Imperial Oil Co., Winnipeg, Ontario
International Contractors, Ltd., Toronto
Kennedy Construction Co., Montreal
Law & Co., 136 Hillsdale Ave. E., Toronto
Merlo & Ray, Walkerville, Ontario
Municipal Concrete Co., Ingersoll, Ontario
Ottawa Construction Co., Ottawa
Palmer & Palmer, Guelph
Ponsford, A. E., Ltd., St. Thomas, Ontario
Quinlan & Robertson, Montreal
Riley, T. E., St. Catherines
Routley & Summers, Haileyburg
Somerville & Dilworth, 36 Main St., N., Welland, Ontario
Souchelli, C., North Bay, Ontario
United Contractors, Ltd., 105 Fountain Hill, Quebec
Walker, H. J., Cornwell, Ontario
Warren Bituminous Paving Co. of Ontario, Ltd., Toronto, Ontario

Colorado

Allen & Maloney, Littleton, Box 84
Boulder Concrete Work, Boulder
Browne, F. A., 1st and Larimer St., Denver
Bu Praw, R. H., Ouray
Burke & Vaughn, Castle Rock
Coleman, E. R., La Veta
Colorado Engineering & Construction Co., Greeley
Croll, P. C., Pueblo
Dewald, M. U., Holly
Fox & Babb, 905 8th Ave., Greeley
Fox & Smith Construction Co., Florence
Fravert, C. W., Rifle
Gaffey & Keefe Construction Co., Denver
Heimbecher & Bro., C. F., 515 15th St., Denver
Herst & Koenig, Sterling
Hess & Son, Manassa
Hokasono Construction Co., 400 Barclay Block, Denver
Holme & Allen Pipe & Construction Co., McPhee Bldg., Denver
Jenkins & Branson, Las Animas
Johnson, J. W., Julesburg
Kilpatrick Bro. Co., Railroad Bldg., Denver
Larson, Christ, Hotchkiss
Lumsden & Gordon, Canon City
Moule, A. A., Ouray
Osner Construction Co., Denver
Pinno, J. E., Fort Morgan
Roberts Construction Co., Fred, Denver
Sheeley Construction Co., The C. G., The Tabor Opera House, Denver
Vickery-Foster & Doll, Denver
Whitney-Steen Co., Symes Bldg., Denver
Zook & Makin, Erie

Connecticut

Ahern Construction Co., Willimantic
Arborio, John, 36 Ward St., New Haven
Arrigoni & Bro., Frank, Middletown
Arthur, W. H., Glenbrook
Balf Co., The Edward, 26 State St., Hartford
Barbara & D'Auriola, 63 Bank St., Waterbury
Barber & Dorio, Waterbury
Beard, B. N., Shelton
Berlin Construction Co., Berlin
Blakeslee & Sons, C. W., New Haven
Brasos & Sons, A., 66 Oak St., Hartford
Brasos & Sons, A., Middletown
Bridges Sons, Inc., Amos D., Hazardville
Cadwell, Archie B., 45 Main St., New Britain
Connecticut & Rhode Island Co., Inc., Meriden
Connecticut Hassam Paving Co., 902 Chapel St., New Haven
Davidson, J., Ansonia
Del Carlo, C., 105 Oneco St., Norwich
De Michiel, John, 58 High St., Torrington
Donhooe Bros., Middletown
Foley, T. F., 23 Quintard Ave., South Norwalk
Kearney, Thomas, Meriden
Lane Construction Corporation, 37 Colony St., Meriden
Long Bros., 80 State St., Hartford
Longhi, Louis, Torrington
Mahon, B. F., New London
Mascetti & Holley, Torrington
Mastrobattisto, Sperry, Bristol
Osborne, H. Sanford, Redding Ridge
Potter, Walter F., North Haven
Redden Construction Co., F. H., New London
Rossi Construction Co., C. A., 151 Franklin St., Torrington
Smith, W. R., Meriden
Sperry Engineering Co., New Haven
Suzio Contracting Co., L., Colony St., Meriden
Suzio, Peter, New Britain
Tracy, A., 200 Olivia Ave., Derby
Tracy, Edw. P., 200 Olivia Ave., Derby
Tryon, C. W., 32 Vine St., Meriden
Valerio, F., Stamford
Vito Construction Corporation, A., Thompson
Webster & Webster, East Hartford
Wilcox, F. A., Norwich
York Hill Trap Rock Quarry Co., Meriden

Delaware

Anderson, Joseph, Delaware City
Clark, John A., 603 West 5th St., Wilmington
Hollingsworth, I. J., Wilmington
Mundy, J. Patrick, 9 E. 4th St., Wimington,
ONeal, John F., Mount Cuba
Stewart & Donohue, Wilmington

District of Columbia

Brenizer Co., Warren F., Washington
Browne & Garkins, 3329 14th St., N. W., Washington

Cranford Paving Co., Washington
Hoyt, Chas. H., Evans Bldg., Washington
Mullin Co., Geo. B., 14th and Kennedy Sts., Washington

Florida

Ackerman & Ellis, Titusville
Biscayne Construction Co., Miami
Bryan & Snyder, Ft. Lauderdale
Bryson & Bryson, Jacksonville
Coats Co., J. G., Ft. Pierce
Collins, Phil., Tampa
Cone, B., Fort Pierce
Davidson, A. L., Kissimmee
Davis & Webb, Tampa
Davis, R. L., Tampa
Edwards Construction Co., Tampa
Fargo Construction Co., Jacksonville
Florida National Vault Co., Lakeland
Foster, Geo. R., Jacksonville
Freedlund Construction Co., Miami
Fritz & Son, J., Dania
Glisson & Hancock, Palatka
Jacobs, N. N., Lake Helen
Johnson, Hamilton. Orlando
Kennedy Construction Co., W. P., Tampa
Langston & Mack, Titusville
Lueckel, C. G., Fort Pierce
Manly, E. P., West Palm Beach
Michel, Geo. W., Titusville
Proudfoot, E. G., Miami
Rapp & Anderson, Plant City
Rhodes, G. W., Woodville
Rogers, F. N., Miami
Southern Concrete & Construction Co., St. Petersburg
Stidman & Hughes, Limestone
Sturgis & Oliver, Fort Lauderdale
Turner Co., C. H., Pensacola

Georgia

Austin Bros, Atlanta
Bosworth, C. L., Rome
Capital Paving & Construction Co., Thomasville
Case & Cothran, Atlanta
Dysard Construction Co., Austell Bldg., Atlanta
Gardiner & Pease, Columbia
Georgia Engineering Co., Augusta
Hardaway Contracting Co., Columbus
Jamieson & Hallowell, Atlanta
Jaudon Engineering Co., H. S., Savannah
Meador, Jr., T. D., Atlanta
McCrary Co., J. B., Atlanta
Pittman Construction Co., Lakewood Ave., Atlanta
Preston-Small Construction Co., Macon
Southern Tile & Stone Co., 101 Wells St., Atlanta
Turner & Mangum, Macon

Idaho

Alsop, E. B., Boise
Farris Construction Co., R. W., Boise
Foster, Sam A., American Falls
Gustafson, J., Boise
Hellmer, Charles, Idaho Falls
Kester, Geo. H., Lewiston
McNally, F., Pocatello
Manly Bros., Boise
Mull, Charles H., Twin Falls
Ostmer, Edw. C., 416 South 10th St., Boise
Payne, C. M., Spokane
Slick Bros., Boise
Spokane Bitu-Mass Paving Co., The, Sandpoint
Sunton, A. C., Boise
Tanner & Cragum, Idaho Falls
Warren Construction Co., Boise

Illinois

Abbott, J. W., Brownsfield
Atkinson & Fishel, Dixon
Allen Construction & Supply Co., Chicago
Augusta Road Improvement Assn., Augusta
Baer, J., Streator
Ball, F. E., Hampshire
Ball & Co., R. E., Ottawa
Barnewolt Construction Co., Peoria
Baum, Ralph, Paris
Beardstown Concrete Construction Co., Beardstown
Birt, Arthur, Decatur
Blome Co., Rudolph S., Chicago
Brass, E. E., Petersburg
Bretz, John E., Springfield
Britton, B. I., Mounds
Brogen, John, Eldred
Burnham & Co., John, Chicago
Caldwell, H. B., Havana
Canterbury Bros., 106 Barker Ave., Peoria
Capitol City Concrete Construction Co., Springfield
Carrico, F. K., Rockford
Carver, G. K., Mt Vernon
Cerney & Fry, Madison St., Forest Park
Charles, W. C., Cairo
Cherry, J. W., Jacksonville
Chesrown, L. V., Olney
Chicago Creosoting Co., 30 N. La Salle St., Chicago
Citizens Construction Co., Chicago
Clough Concrete Construction Co., Quincy
Cocking Cement Co., Jacksonville
Commonwealth Improvement Co., Chicago
Conducive Paving Co., Forest Park
Conner & Son, S. A., Newton
Connery, C. & B., Paris
Conway Co., R. F., Chicago
Coughlin, F. P., 534 Stock Exchange, Chicago
Crane, J. E., & B. S., Murphysboro
Crane Co., J. E., & B. S., Fairfield
Curdie & Manpin, Alton
Dandrea & Rossie, Chicago Heights
Danville Lime & Cement Co., Danville
Dees & Co., Stanley, Oblong
Degenhardt, Charles, Alton
Dempsey, Frank, Quincy
Duffy & Hubbard, Dixon
Dunlap, O. M., Edwardsville
Dunlop-Dippold Construction Co., Edwardsville
Eclipse Construction Co., Winnetka
Egan, R. F., Springfield
Eiff & Son, Jas., Quincy
Fahrig, Albert, Edwardsville
Federal Construction Co., 1700 S. Washington St., Peoria
Fentz, Edward, Highland
Fernondue & Sons, Jacksonville
Finley, H. C., Hoopeston
Flodin, B. A., 3204 N. Clark St., Chicago
Ford, L. E., Paris
Galvin, M., Cairo
Gasaway, T. A., East St. Louis
Gass, H. C., Belleville
Goelitz, H. G., 810 North Blvd., Oak Park

Goggin, P. J., Arcola
Good Roads Construction Co., Chicago
Granite City Lime & Cement Co., Granite City
Grohne Contracting Co., Joliet
Gund Graham Co., Freeport
Hames, C. M., Jerseyville
Harlan, Wallace, M., Greenville
Harshman, L. B., Sullivan
Heaton, Ed. M., Marion
Helm, W. S., 315 Milligan Bldg., Decatur
Henerfouth, John, Valmeyer
Hess & Wilson, Sterling
Hinden & Son, John, Pana
Hoeffken, Bro., Belleville
Hoffman, Otis, Jacksonville
Holliday, W. R., Cairo
Hough & Son, Wm., Marion
Humndert, H. B., Quincy
Hyten, G. R., Edwardsville
Illinois Hydraulic Stone & Construction Co., Elgin
Jansen & Zoeller, Pekin
Johnson & Co., P. M., St. Elmo
Johnson Construction Co., 115 South Dearborn St., Chicago
Johnson, H. P., Sterling
Kunkel, W. O., Carthage
Lacy, E. R., Knoxville
Lain, I. D., Bloomington
Lehigh Stone Co., Kankakee
Lodge, W. F., Monticello
Logan & Viertz Construction Co., Elgin
Loomis Co., A. C., 1816 Lafayette Ave., Mattoon
Lord, E. A., Monmouth
Lough & Son, W., Marion
McAllister, John, Peoria
McCabe & Maule, East St. Louis
McCaughey, J. J., West 90th & Holland Rd., Chicago
McCauley, J. B., Galesburg
McConnell, J. W., Carthage
McElwell & Bushell, Peoria
McGarrock Bros. Contracting Co., Chicago Heights
McGarry & Co., J. A., 189 West Madison St., Chicago
McKnight, L. A., Robinson
McMorris, R. H., Greenup
McWilliams, R. H. & G. A., 1111 McCormick Bldg., Chicago
Mannen, Jerome, Mt. Vernon
Marquette Construction Co., Chicago
Medaris Construction Co., R. A., Springfield
Mehaffy, John E., Quincy
Meyer & Thomas Construction Co., East St. Louis
Michael, G. A., Mattoon
Michelman Steel Construction Co., Quincy
Miller & Husband, Springfield
Mink Brothers, Paris
Morava Construction Co., Chicago
Mulvill Bros., Box 81, Alton
Murphy, D. E., Pana
Myer & Thomas Construction Co., Murphysboro
Nelch & Son, Henry, Springfield
O'Loughlin, J. J., 133 W. Washington St., Chicago
Oswald Bros., Alhambra
Patterson & Co., J. O., Springfield
Payne, Charles, Waukegan
Peerless Engineering & Construction Co., Glenellyn
Polk Concrete Construction Co., 1507 66th St., Chicago
Porter, Charles M., Chicago
Pratt, John, Virginia
Pronger & Fletcher, Blue Island
Prosser & Halliday, Cairo
Proudfoot, F. G., 127 N. Dearborn St., Chicago
Public Service Construction Co., E. Peoria
Reeb Bros., Belleville
Rees, H. J., Quincy
Roetzlet & Chipman, Mt. Carmel
Rutledge, A. E., Rockford
Ryan, David, Alton
Ryan Construction Co, D. J., Moline
Sackley, James A., Chicago
Salfisberg & Co., J. E., Aurora
Sarff, John A., Virginia
Saxton Co., S. S., 332 S. Michigan St., Chicago
Schilling, John, Dolton
Sell & Kollar, Pana
Serbian, Julius, Cairo
Shanahan, R. F., Quincy
Shidler, F. L., Kankakee
Shields & Co., Ewing, Joliet
Shields, J. C., Chicago
Sieur Bros., Dallas City
Simmons, Peter, Quincy
Smith, Sam, Streator
Smith & Brown, Chicago
Snyder & Barnett, Brockton
Standard Paving Co., Chicago
Stewart, Jim, Freeport
Stipes & Pilcher, 108 N. Walnut St., Champaign
Stipes, J. W., Champaign
Stocker Gravel & Construction Co., Highland
Strubel, John, Alton
Swarts, G., Streator
Taggert, Claude, Martinsville
Taylor, Frank, Belvidere
Thompson Co., A. D., Peoria
Todd, A. N., Chicago
Toliver, W. R., Noble
Trenkensch, P. F., Rock Island
Tri-City Construction Co., Rock Island
Tuckey, Richard, Monmouth
Tuttle, S. A., E. Prairie St., Decatur
Uhde, W. H., Greenup
Upton, D. F., Odell
Van Dusen & Baumberger, Greenville
Vogt, John D., Belleville
Walter, W. J., Glencoe
Ward & Son, Andrew, Oak Glen
Ward, F. J., 28 E. Jackson St., Chicago
Waukegan Improvement Co., Waukegan
Welch & Son, Henry, Springfield
Western Bader Pipe Co., Monmouth
Western Road Tool Co., Monmouth
Wever & Son, C. A., Clayton
White Paving Co., Chicago
Williams, Roy, Cairo
Williston Construction Co., Chicago
Wolf, Riley, Alton
Wright, James V., Harvard
Zolpher & Sons, Henry, Mendota

Indiana

Ackerman & Co., Jake, Laporte
Ahlborn Construction Co., Hammond
Aikman, Peter, Dana
Ajax Constructing & Engineering Co., Gary
Allen & Co., W. E., Hillsboro
Allen-Hurst & Sweet, Greencastle
American Construction Co., Indianapolis
Appleman, F., Plymouth

Arkansas Construction Co., Mt. Vernon
Arkansas Construction Co., Vincennes
Athey & Slepton, Greencastle
Barber, Ross, Flora
Barnes Co., A. H., Logansport
Barnes, Harry W., South Bend
Bassett & Sullivan, Morristown
Bassett, W. N., Morristown
Baylor, Chas. M., Versailles
Beard, Chas. W., Oaktown
Bearst Co., L. O., Geneva
Beckman, Jr., Albert H., Patriot
Bennett & Co., R. C., Indianapolis
Bentley & Hill, Greenfield
Bergen & Jeffery, Franklin
Birch, Wm., Muncie
Blackmore & Ludlow, Lawrenceburg
Blackmore, R. H., Lawrenceburg
Blair & Kerr, Bloomington
Blunck & Van Arsdale, Martinsville
Brady Construction Co., W. B., South Bend
Brandt & Co., N. L., Frankfort
Brannock, James, Lowell
Briggs, Guy H., Clinton
Brineman, Clem S., 422 W. South St., Bluffton
Brooks Construction Co., Angola
Brown & Pilcher, Bargersville
Buckmaster & Huey, Geneva
Burk, James, Anderson
Burke & Durbin, Anderson
Byers & Byers, Trafalgar
Byers, E. H., Monroe City
Cain, W. A., Gary
Camblin, F. A., Morocco
Campbell & Hawkins, Brazil
Carpenter Construction Co., Terre Haute
Carpenter, H. A., Cloverland
Carty, W. G., Rockville
Cahmness, Wm. M., Winchester
Chapman, G. R., Clinton
Chastain, A. E., Salem
Clark, Chas. W., R. F..D. No. 1, Clinton
Clark, N. H., Bedford
Clevenger, David B., Rochester
Cline & Moore, Muncie
Cohee, A. F., Frankfort
Coin, William, Frankfort
Cole, Grant D., R. R. No. 1, Lafayette
Coleman, Henry, Logansport
Coley & Miller, Winchester
Connell, T. J., Cambridge City
Conner & Sherry, Connersville
Cornelius-Paulin & Co., Cannelton
Coulson & Angermeier, R. R. No. 1, Inglefield
Courtright, A. L., Crown Point
Creasey & Son, J. W., Terre Haute
Crider, Geo. W., Greenfield
Cripe & Seaman, Goshen
Cronin, J. F., Richmond
Crouse, T. N., Clay City
Crum & Stoneburner, Decatur
Culbertson & Culbertson, Richmond
Cunningham Construction Co., Martinsville
Curtis & Curtis, Muncie
Curtis, E. M., Muncie
Cutler & Yeagy, Gary
Dale, C., Lebanon
Dalton, D. J., Anderson
Daniels-Lyst & Douglas, Anderson
Davenport, F., Kokomo
Davis Construction Co., Arcadia
Deferes, C. H., South Bend
De Golyer, James, Seymour
Dellinger, Logan, Jeffersonville
Dickson, W. J., Kokomo
Dillinger & Luts, Charleston
Dillon, William, Anderson
Dorris, J. B., 229 E. Washington St., Sullivan
Downey & Bortz, Hammond
Dreery, I. M., Richmond
Drook & Rich, Marion
Ellison & Co., Monroeville
Erganbright & Disney, North Salem
Everroad, J. C., Columbus
Fatout, D. H., Indianapolis
Faubion, L. C., Bedford
Federal Asphalt Paving Co., Wabash
Fish, Max, La Porte
Flanagan, S. T., St. Croix
Fleetwood, J. Matt, Kirtz
Floyd & Son, M. C., Farmersburg
Foley Construction Co., Elkhart
Foster Construction Co., Richmond
Fougervouse, Frank, New Albany
Foulks Construction Co., Vincennes
Frank & Sons, L. W., Decatur
Freeland, A. J., Freeland Park
Fridy, J., R. R. No. 4, Evansville
Fry, A. H., 503 E. South St., Bluffton
Games, Samuel T., R. R. No. 3, New Albany
Gant, Edward G., Greenfield
Gary Construction Co., Gary
Gerber, David, Decatur
Ginn, C. F., Frankfort
Gordon & Brennaman, Bluffton
Gordon & Son, W. S., Bluffton
Grace Construction and Supply Co., Fort Wayne
Graninger, John, Jeffersonville
Gray, C. E., Fowler
Grosjean & Roemer, Fort Wayne
Grosnickle Construction Co., North Manchester
Gross Brothers Construction Co., La Porte
Guinnup, M. M., Muncie
Hall, Joseph, Logansport
Hamilton Co., T. G., La Porte
Harley & Trant, Hartford City
Harshban & Harrell, Frankfort
Hatch & Carvey, Macy
Hatch & Sons Co., W. W., Goshen
Hay, Melvin, Rochester
Hayes, M. J., Indianapolis
Haynes & Waymire Independence
Heber & Ingram, Newport
Heston, Amos, Ridgeville
Heston, Isaac, Winchester
Hiatt, G. Walter, Winchester
Hines, Frank, Muncie
Hinshaw, Seth, Winchester
Hipskind, John, Richmond
Hobon & Roach, South Bend
Hodson-David Construction Co., Michigan City
Hodson-David Construction Co., Gary
Holman, Hugh, Rochester
Hoppes, Geo. M., Anderson
Hoppes, Geo. M., Greenfield
Howe, John, New Albany
Huffman & Son, E., Warren
Hulse, William, Scipio
Hutchinson, W. B., Michigan City
Hutton-Harris Co., North Vernon
Hyman, D. A., Logansport
Iliff, Harry, Union City
Illinois Improvement & Ballast Co., Gary
Indiana Asphalt Paving Co., Indianapolis
Ingram & Co., Hillsdale
Irvin, C., Covington
Irwin, Charles, Attica
Jacobs, Wendel P., Madison
Jennings & Bebout, Seymour
Jester & Jester, Perrysville

Johnson & Dull, Winchester
Jones, Oscar L., Columbia City
Jordan, Leroy, Columbus
Kain, C., Medaryville
Kattmann & Hancock, Brownstown
Keefer & Bailey, Huntington
Keegan Bros., Brazil
Keane, A. S., Wheatland
Kellerman & James, N. Judson
Kelly, T. P., Anderson
Kelly & Emeley, Bippus
Kent Construction Co., F. H., Shelbyville
King & Co., C. C., Indianapolis
King, Frank J., Masonic Temple, La Porte
Kirkpatrick, C. M., Greenfield
Kirkpatrick, C. M., Indianapolis
Klein, Charles F., Edinburg
Knit Construction Co., F. H., Shelbyville
Kokomo Asphalt & Paving Co., Kokomo
Langford & Langford, Paoli
Lassell, M. L., Clay City
Laverne, Thos., Hammond
Lavine Bros. Co., Hammond
Layne & Sons, P. H., Crawfordsville
Lehmer & Co., E. E., North Manchester
Lisby, A. M., Coatesville
Ludlow, Frank, Lawrenceburg
Lybarger & Presey, Lynn Grove
Lyons & Delaney, Muncie
McAfee & O'Connor, Fort Wayne
McBride, James, Bedford
McDonald & Son, E. L., Lebanon
McGillicuddy, Gerald, Valparaiso
McKee & Co., E. E., Williamsport
McKensey & Jenkins, Frankfort
McPike Bros., Bedford
Maggard, Edgar L., Austin
Mahoney, Edw., Churubusco
Mahoney, Edw. D., Lafayette
Marley, Chas. H., Moorsville
Martine, Louis, La Porte
Masters Construction Co., Seymour
Mathys, Smith, Berne
Meshberger, Harry, Decatur
Metz & McVey, Gary
Miles, James E., Madison
Miller & Miller, Mauckport
Miller, G. T., Lebanon
Miller, John L., Miami
Milliken & Socks, Noblesville
Minnex, Chas. T., Flora
Moellering Construction Co., Fort Wayne
Moneybun & Son, I. W., Monticello
Moore, J. B., Logansport
Moyer & Goodall, La Porte
Mulvihill, Thos., Terre Haute
Nees, W. J., Frankfort
Neidhart & Co., W. J. Anderson
Neijdhl & Greenwald, Whiting
Neil & David Construction Co., Gary
Ness, William J., Frankfort
New & Son, Thos., Greenfield
Newhouse, Wm., New Albany
Northern Construction Co., Goshen
Northern Construction Co., Elkhart
North Indiana Construction Co., Nappanee
North & Co., C. W., Bluffton
Nugent, G. T., Hartsville
O'Connor, Robert E., Fort Wayne
Oilar & Parlan, Lafayette
Oilar, Benjamin, Battle Ground
O'Neil, Martin F., Jeffersonville
O'Leary & Sons, P., 25 S. 13½ St., Terre Haute
Palmer & Co., Geo. H., Logansport
Palmer, Moore & Co., Logansport
Palmer, Samuel, Huntington
Parker Co., W. W., Hammond
Pass, William, Sellersburg
Patton & Son, E., Veedersburg
Peterson, Archie, West Point
Polk & Co., Oaktown
Polly, G. W., Elkinsville
Portz, Al., Hammond
Premier Construction Co., Indianapolis
Prentiss & Case, French Lick
Pickens, W., & Terry, W. W., Cloverdale
Prutzman, T. F., Muncie
Rankert & Eggleston, Mishawaka
Rector, C. V., Muncie
Redington, Chas. E., Greensburg
Reed & Sons, H. M., South Bend
R. E. M. Construction Co., Evansville
Rennenschneider & Anstis, Winamac
Republic Construction Co., Indianapolis
Rice, M. L., Monon
Richard & Scribner, Crawfordsville
Robbins & Rogers, Knox
Rook & Co., Dunkirk
Rusk, F., Hillsboro
Salvin, Orvis, Tefft
Scamahorn, Gene, Rockport
Schafer, O. E., Royal Center
Schaner, C. B., Greencastle
Schneider Bros., Richmond
Sexton & Bolt, Shelbyville
Seymour, G. G., Noblesville
Shahan & Son, P., Lebanon
Shattuck, Austin M., Brazil
Shearer, C. C., Crown Point
Shields Co., Ewing, Greencastle
Short, H. L., La Crosse
Shutt, L. A., Huntington
Slick, F. E., Richmond
Smith, Amandus M., Elkhart
Smith-Carter Co., Indianapolis
Smith, I. E., Richmond
Smith, Selma, Gary
Smith & Co., W. F., Rensselaer
Snyder, J. M., Muncie
Snyder Co., J. M., Frankfort
Sparks, Thomas E., Kirklin
Sprinkle, W. R., Portland
Stagg, Thompson & Davis, Greensburg
Stalbaum, Geo., Tefft
Stewart Construction Co., H. H., Kokomo
Stull & Gaither, Smithville
Sullivan, Ray N., Peru
Sweeney & Green, New Albany
Sweeney, Wm. A., Jeffersonville
Sweeney & Co., W. O., Jeffersonville
Sykes, Charley, Newport
Sykes, Geo. W., Dana
Teach, Frank, Crown Point
Temple, B., Somerset
Terrence, Wm., Muncie
Thomas & Davis, Greensburg
Thomas & Thomas, Mount Vernon
Thomas, Lawrence, Mt. Vernon
Thompson & Davis, Greensburg
Thornburg, Petro & Ross, Winchester
Timberlake, S. M., 1434 Broadway, Indianapolis
Tolleston Concrete Co., Gary
Torrence, W., Muncie
Trapper, A. G., Peru
Treece, Chas. J., Elizabeth
Union Asphalt Co., Indianapolis
Unison, John I., Terre Haute
United Paving & Construction Co., Indianapolis
Utley, L. J., Mt. Vernon

Walker, I. J., Huntington
Ward, Thomas, Otterbein
Watson & Co., J. H., Kokomo
Webber, G. A., Morocco
Western Construction Co., Mishawaka
Wilk & Co., Rushville
Wilson, T., Brookville

Iowa

Aiken & Flutter, Corning
Aiken & Flutter, Ames
Anderson & Olson, Marshalltown
Anderson, B. R., Marion
Baker, R. F., Oskaloosa
Balzer, F. F., Des Moines
Berry, J. L., Iowa City
Blunk, J. C., Ottumwa
Blythe Bros., Tama
Bowen, S. R., Mason City
Bradley, T., Iowa City
Bryant Asphalt Paving Co., Waterloo
Burlington Construction Co., Burlington
Cameron, Joyce & Co., Keokuk
Carey & Sons, Thomas, Clinton
Carter, W. B., Sioux City
Central Engineering Co., Davenport
Chilton, Chas., Ottumwa
Clarke, P. V., Clinton
Collins, G. S. C., Sioux City
Dearborn Construction Co., Waterloo
Dearborn & Jackson, Cedar Rapids
Decorah Cement Sidewalk Co., Decorah
Dennis, Lewis H., Marion
Des Moines Asphalt Co., Des Moines
Donnelly, John, Gilmour City
Dutton, Wm., Boone
Elsy & Carlson, Marshalltown
Flynn Paving Co., M. L., Sioux City
Flynn Paving Co., M. L., Denison
Ford Paving Co., Cedar Rapids
Gabler, Geo., Mason City
Gochanour, E. L., Muscatine
Grimm, J. G., Wapello
Guenther, F. W., Burlington
Hahn, F. K., Cedar Rapids
Hanlon & Oakes, Sioux City
Hanlon, E. J., Sioux City
Hansen & Son, P. C., Sioux City
Hansen, W. E., Ringstead
Hoar & Parkinson, Iowa City
Horrabin & Co., James, Des Moines
Horrabin, Wm., Iowa City
Hydraulic & Concrete Construction Co., Davenport
Iowa Cement Brick Co., Sioux City
Jensen & Krage, Sioux City
Korneman & Smith, Muscatine
Kughn, J. E., Dows
Lee Contracting Co., The James, Dubuque
Lee, J., Dubuque
Lewis & Leeder, Sioux City
Littig Construction Co., The, Davenport
McCarthy Improvement Co., Davenport
McNamara & Co., C. B., Dubuque
Miner, L., Monticello
Newton, H. R., Missouri Valley
Peterson, Geo. Burlington
Reed, S. B., Dolliver
Rink & Schnell, Clinton
Samuelson, E. H., Boone
Smith, Percy P., Cedar Rapids
Sweat, B. J., Cedar Rapids
Thirn Paving Co., M. L., Sioux City
Ward, R. L., Correctionville
Western Construction Co., Sioux City
White Construction Co., 1006 Railway Exchange Bldg., Clinton
Williams & Wisnell, New Sharon
Wilson Co., Red Oak
Wood & Co., L. C., Alden
Young & Buescher, Burlington
Zitterell & Sullivan, Webster City

Kansas

Acme Paving Crusher Co., Kansas City
Beebe Construction Co., Hutchinson
Besler Construction Co., Chas. L., Winfield
Boddington, D. M., Kansas City
Bowesman, D. P., Rosedale
Canatsey & Hibbens, Independence
Clements & Lavery, Coffeyville
Cleveland Trinidad Paving Co., Wichita
Cook, A. L., Ottawa
Davidson Construction Co., Independence
Deeter & Wenzel, Wichita
Dodson, W. C., 2136 Orville St., Kansas City
Everett & Burt, Hutchinson
Fenton & Co., H. B., Kansas City
Gardiner, Chas. H., Fort Scott, Box 472
Jaicks Co., A., 508 American Bank Bldg., Kansas City
Kaw Paving Co., Topeka
Kelly, J. D., Overland Park
McCune, Fred G., Wichita
Miles, H. L., Wichita
Nesh, H. R., Pittsburg
Petty, J. H., Paola
Ranson & Cook, Ottawa
Robson Construction Co., Pittsburg
Rondebush, G. G., Kansas City
Taylor, Perry, Chanute
Thogmartin & Gardner, Fort Scott
Turner, Archie M., Rosedale
Watts & Ammerman, Salina
Watts & Ammerman, Concordia
Wheeler & Keleher, Hutchinson
Yale Construction Co., F. W., Coffeyville
Young, A. R., Lawrence

Kentucky

American Concrete Construction Co., Louisville
American Standard Asphalt Co., Louisville
Armstrong & Grubbs, La Center
Barker, K. A., Louisville
Bickel & Co., Henry, Louisville
Blue Grass Construction Co., Bardstown
Brickel Asphalt Paving Co., Louisville
Buckel Co., H., Louisville
Burgess & Co., Fullerton
Cahill, J. H., 1540 S. 9th St., Louisville
Carey-Reed Co., Lexington
Carter, L. E., Lovelaceville
Central Construction Co., Lexington
Clark County Construction Co., Winchester
Conly Construction Co., Somerset
Consolidated Coal Co., Jenkins
Coombs, S., Carrollton
Cresap Bros., Greenville
Crowder, C. K., Henderson.
Durrett Construction Co., Louisville
Estes & Woods, Lebanon
Figg Co., L. L., Louisville
Fletcher & Peak, Elizabethtown
Frazer, R. L., La Center
Frazer & West Kentucky Construction Co., La Center
Gonnell Co., G. W., Louisville
Gormley Bros., Versailles
Gorrell, R. L., Russellville
Gosnel Co., G. W., Louisville
Grenier Co., J. L. V., Clinton
Hagard, D. S. B., Winchester
Haggard, Brent, Winchester
Hanerck Co., L. W., Louisville
Harris, C., Covington

Hedger, Zach, Covington
Henson, Coop, Franklin
Home Construction Co., Lexington
Jefferson County Construction Co., Louisville
Justice & Co., F. T., Lexington
Katterjohn, G. W., Paducah
Kirk, Smallwood & Kirk, Russell
Kuepfle, Edw. J., Bellevue
Larson, Edwin S., Louisville
Louisville Asphalt Co., Louisville
Luts, William, Lexington
Manion, E., Henderson
Mason Construction Co., Emanuel
Metzel & O'Hearn, Covington
Montgomery, Perkins & Co., Hopkinsville
Newman J. H., Tompkinsville
O'Hearn & Metzel, Covington
Price, Rhea, Auburn
Reed Co., Carey, Lexington
Rhodes, N. E., Lynnville
Schoolfield, R. L., 816 Columbia St., Newport
Sharp, G. P., Middlesboro
Stone, N. E., Madisonville
Van Diver, J. Harvey, Harrodsburg
Van Petten & Co., O. W., Greenup
Vastine, Nowlands & Lohre, Covington
Vermillion & Son, T. J., Barbourville
West Kentucky Construction Co., Wickliffe
Winchester Construction Co., Winchester
Woodruff, W. F., Station "A," Louisville

Louisiana

Albee, F. A., Natalbany
Alexander, L. F., Audubon Bldg., New Orleans
Allen, A. A., Bayou Goula
American Developing Co., 908 Hennen Bldg., New Orleans
Bancroft Bros., New Orleans
Barrow, B. F., Marganza
Bettery, M., Marksville
Blakemore, A. B., 702 Hennen Bldg., New Orleans
Brady, E. P., Macheca Bldg., New Orleans
Buras, J. L., Buras
Calongne's Sons, S. A., New Orleans
Carbo, B. J., Alexandria
Cavet, W. R., Box 312, Shreveport
Chaudoir, O. J., Alexandria
Comerford, W. J., 427 Pennsylvania St., New Orleans
Conrad, Geo. H., 5005 Dauphine St., New Orleans
Constant, Francis T., P. O. Box 220, Alexandria
Craven & Co., J. A., 913 Hibernia Bldg., New Orleans
Dalgram, L. M., 218 Barronne St., New Orleans
De Jersey & Naff, Opelousas
Doullut & Williams, New Orleans
Egan, Thos., 4330 Canal St., New Orleans
Egliston, Howard, 1910 Hibernia Bldg., New Orleans
Epple, Geo., Shreveport
Favret, L. F., 311 Barronne St., New Orleans
Gailey, A. J., Alexandria
Garig, Geo. W., Baton Rouge
Garsaud, Marcel, 2106 Tulane Ave., New Orleans
George & Sons, J. W., Baton Rouge
George & Ransbottom, Alexandria
Geren, W. E., Columbia
Glassell Bros., Belcher
Grasser Contracting Co., 912 Hennen Bldg., New Orleans
Hale, C. M., New Orleans
Hedberg, Herman, 4602 Perrier St., New Orleans
Helperin & Nattin Construction Co., Shreveport
Hicks Co., Shreveport
Hudson Construction Co., Alexandria
Hunt, M., Shreveport
Hunter, S. S., Shreveport
Huth Dredging Co., Franklin
Ivey, D. E., Mer Rouge
Jackson, C. S., Crowley
Jahncke Navigation Co., New Orleans
Jones, S. K., Transylvania
Kane-Kelly Construction Co., New Orleans
Keegan Sons, John J., 2824 Magazine St., New Orleans
McManus Bros., Eros
Martin, Chas. J., 1544 Allen Ave., Shreveport
Mendelson, Chas., 339 Carondelet St., New Orleans
Nattin, J. H., Belcher
Newman & Wilds, Venneer
Nicholson, Robert, Lake Providence
North Louisiana Construction Co., Benton
Patterson, A. L., New Orleans
Picou, Wallace, McCall
Pratti, N., 2817 Onzaga St., New Orleans
Ransbottom, C. E., Alexandria
Reynolds, Hampton, 7823 Birch St., New Orleans
Rushing, W. M., Bayou Current
Ryan, J. E., 4218 Iberville St., New Orleans
Scott, N. G., Hennen Bldg., New Orleans
Simms, J. M., Alexandria
Smith Bros., Coushatta
Stevens, W. L., New Orleans
Teche Transportation & Fuel Co., The, Franklin
Tioga Gravel Co., The, Alexandria
Thomas, A. J., 208 Hibernia Bldg., New Orleans
Wetzel & Co., Alexandria
Williamson, Norris, Milliken
Wimbish, C. D., Shreveport
Wood, B. D., Whitney Central Bank Bldg., New Orleans

Maine

American Truck Co., Kittery
Benedict, C. T., Pittsfield
Berg, John A., Brownville
Clifford, John D., Lewiston
Cunningham, F. W., Portland
Dougherty, Wm. J., 26 North St., Portland
Fales & Simon, Rockland
Forgione & Romans, South Portland
Goodwin, Roy C., South Berwick
Grady & Sons, John, Bangor
Gulliver, John W., 120 Exchange St., Portland
Hughes, Murtagh, Bangor
Lord, Edgar I., Bar Harbor
Mahoney Construction Co., 86 Market St, Portland
Maine Trap Rock & Construction Co., Portland
Mitchell, E. T., Oakland
Murray Bros., Bangor
Murray, Chas., Houlton
Neally Co., J. Barton, Bangor
Noyes & Campbell, Augusta
Sawyer & Moulton, Portland

Small & Ingalls, Bar Harbor
Small & Ingalls, Bangor
Smith & Havey, W. Sullivan
Tilton, S. D., Lewiston

Maryland

American Bridge Co. of New York, Baltimore
American Paving Co., Baltimore
Andrew Contracting Co., David M., 600 Equitable Bldg., Baltimore
Andrews, S. S., Cambridge
Arundel Construction Co., 329 S. Caroline St., Baltimore
Ault, D. V., Baltimore
Austin Bennett Construction Co., Knickerbocker Bldg., Baltimore
Baker & Smith, East New Market
Baltimore Asphalt Block & Tile Co., Lowman and Monroe Sts., Baltimore
Bennett & Hunter, Westminster
Bester & Long Co., Hagerstown
Brown, E. W., Port Deposit
Caroline Construction Co., Preston
Carozza & Christhilf, 606 Munsey Bldg., Baltimore
Carozza, Frank, Munsey Bldg., Baltimore
Chesapeake Construction Co., Preston
Claiborne, Johnston & Co., Baltimore
Coblentz & Klipp, Frederick
Consolidated Engineering Co., 255 Calvin Bldg., Baltimore
Cross, F. C., Equitable Bldg., Baltimore
Dinterman, L. G., Walkersville
Duvall, F. M., St. Margarets
Elder Paving & Contracting Co., Baltimore
Filbert Paving & Contracting Co., Baltimore
Fisher & Carozza, Baltimore
Flanigan & Sons, Patrick, Baltimore
Forsythe, T. C., Belair
Fuller Bros., Frostburg
Gatch & Sons, Thos. B., Raspeburg
Gaylord, Brooks & Co., 20 E. Lexington St., Baltimore
Grossman, F. C., Equitable Bldg., Baltimore
Grove, M. J., Lime Kiln
Guilford & Walterville Granite Co., 11 E. Lexington St., Baltimore
Highway Construction Co., Frederick
Holt Construction Co., Federalsburg
Hope Construction Co., Denton
Isle of Wight Land Co., Ocean City
Jewel, Geo. W., Annapolis
Kaylor, H. W., Hagerstown
Kean & Clark, Cumberland
Laner & Harper Co., Baltimore
Long Contracting Co., George, Baltimore
Martin, J. W., Annapolis
Maryland Amiesite Stone Co., 15 E. Fayette St., Baltimore
Mays, B. H., Glencoe
Messenger, R. W., Federalsburg
Mullan, T., Baltimore
Nichols Bros., 214 Courtland St., Baltimore
Padgett, Robt. J., 809 N. Broadway, Baltimore
Peninsula Construction Co., Preston
Phillips & Andrews, Hurlock
Reddington, P. F., 321 St. Paul St., Baltimore
Rich, Upshar D., 3205 Clifton Ave., Baltimore
Richardson & Williams, 847 Equitable Bldg., Baltimore
Schneider Paving Co., F. E., Baltimore
Sell Bros. Co., Cumberland
Slingluff-Browne Co., 1405 Munsey Bldg., Baltimore
Spencer, J. E., Aberdeen
Stehle & McGuckian, Annapolis
Stover, W. J., Phoenix
Swann, H. S., Faulkner
Sweeton & Sons, B. F., Baltimore
Talbott Co., M. A., Baltimore
Thomas, Bennett & Hunter, Westminster
Vang Construction Co., Cumberland
Waesche, L. R., Thurmont
Walsh, D. E., Westminster
Warren Ehret Co., Baltimore
Whiting-Turner Construction Co., Sexton Bldg., Baltimore

Massachusetts

Achenbach, U. U., 119 Broadway, Haverhill
Acushnut Construction Co., New Bedford
Adams, Edward, North Andover
Alger, C. T., Taunton
Armor Concrete Construction Co., John Hancock Bldg., Boston
Atkins, Geo. A., Palmer
Atlas Co., 832 Old South Bldg., Boston
Baker, Chas. I., 26 Hurlburt St., Cambridge
Barton, Cyrus, 78 S. Walker St., Lowell
Bartholomew, E. U., Sheffield
Batchelder, I. T., North Redding
Beaver Construction Co., 195 Fern St., Pittsfield
Benedict, Olin T., 1266 North St., Pittsfield
Bermudes Co., 246 1st St., East Cambridge
Biggs & Co., D. M., 108 Marsh St., Dorchester
Blakney, B., Groton
Blood, W. H., South Lancaster
Bradley, Micheal A., Blackstone
Bruno, Thomas, East Boston
Bruno, Thomas, 76 Vane St., Revere
Bryne & Co., Geo. M., 79 Milk St., Boston
Bullard, O. O., Sterling
Burnett, H. & D., Franklin Park, Revere
Burnham & Poor, North Andover
Camarco, Michael L., Lee
Carchia, A., East Weymouth
Carchia, L. C., 158 Salem St., Boston
Carr Co., G. W., 518 Main St., Worcester
Cashman Bros., Newburyport
Cellilli, C. I., 303 Water St., Springfield
Central Construction Co., 228 Southampton St., Roxbury
Chilson & Co., D. L., Franklin
Cinadella Bros., Co., Milford
Coleman Bros., Pearl & Marginal Sts., Chelsea
Coleman & Sons, J. C., 1620 Tremont St., Roxbury
Collins, John, Newburyport
Condon & Martin, Watertown
Connolly Bros., Beverly Farms
Connor Bros., Lowell
Converse & Co., H. P., 120 Milk St., Boston
Cordner & Montague, 433 Bay St., Springfield
Cressy, Walter, Gloucester
Crimmings, Dennis I., 217 Power House Blvd., Somerville
Crowe & Walsh, Pittsfield
Cushing, Herbert, Seekonk
Dallesandro, Charles, Chester
Damon, David H., Ashby
Davis & Brock, Brookline
Davis, W. T., Canton

DeMarco, Joseph, 130 Shrewsbury St., Worcester
De Matteo, M., 146 Dudley Ave., Roslindale
De Staphano, A., 61 Maverick Sq., East Boston
De Vito, J. A., Mystic Valley Parkway, West Medford
Doherty, James, 133 Calumet St., Roxbury
Driscoll, D., 21 Kent St., Brookline
Driscoll & Son Co., James, Brookline
Dyar Supply Co., 510 Main St., Cambridge
Eichorn, F. H., 31 Astican Road, Forest Hills
Elkins Co., P. B., 8 Beacon St., Boston
Ellis, Fred E., Melrose
Fannon, Jas. H., 28 Hinckley St., Somersville
Fay, Frank T., 50 Congress St., Boston
Ferguson, J. H., Dorchester
Ferullo & Co., G., Boston
Figenbaum, F., Leominster
Fitzgerald, A. W., Marlboro
Flynt Granite Co., Monson
Framingham Construction & Supply Co. Framingham
Gaffey, John A., Medford
Galle, C. D., 326 North St., Boston
Gilbert, F., 326 North St., Boston
Gill, John F., 92 Bonair St., Winter Hill
Gill, T. H., Boston
Giovannini, P. F., 424 Hanover St., Boston
Globe Construction Co., Old South Bldg., Boston
Grant, Bernard E., Boston
Hamlin & Ryan, Salem
Hammond & Bro., D., Pittsfield
Hammond, F. W., Beverly
Hanscomb, H. A., Monument St., West Medford
Harrigan, J. J., 60 Pleasant St., Beverly
Hassam Paving Co., 390 Main St., Worcester
Hodges, Arthur, 147 Milk St., Boston
Holbrook, Cabot & Rollins, Boston
Horne, Chas. E., Milbury
Hub Construction Co., 163 Harrisheff St., Roxbury
Hudson, R. F., 19 Whittier St., Melrose
Jacobs & Co., Charles J., 107 Terrace St., Roxbury
Jenks-Williams Paving Co., 1 Walker Bldg., Worcester
Johnston, Jas. H., 17 Boardman St., Newburyport
Keating & Co., J., Fitchburg
Keith, Warren R., 1489 Main St,. Campello
Kelly & Sullivan, 25a Cherry St., Somerville
Kenney, Michael, 553 Cambridge St., Worcester
Kernan, J. W., Highland Club, Lowell
Kettle Brook Stone Co., 96 Stafford St., Worcester
Kiely & Gleason, Northampton
Killorin Contracting Co., 6 Walnut St., Wakefield
Kitfield, E. H., 46 Cornhill, Boston
Lane Quarry Co., Hingham
Langevin, Aimoe, 6 Snow St., South Bridge
Lavelle, H., Quincy
Leach, C. N., P. O. Box 2285, Boston
Leadbetter & Sons, G. E., 6 Cottage St., Leominster
Letteney, John H., 101 Tremont St., Boston
Lewis, J. S., Williamstown
Ley Construction Co., Fred T., Springfield
Lineham, John, Beverly Farms
Long & Co., Joseph, Leominster
Lowd & Son, W. E., Quincy
Luchini-Mazani Co., Milford
McBride, H. M., 10 Winship St., Brighton
McCarthy Bros., Franklin
McCourt Co., John, 36 Waite St., Roxbury
McCusker, J. H., 62 Church St., Waltham
McDonough Co., M., Swampscott
McGill & McComiskey, Dover
McGovern, James, Adams St., Dorchester
McGovern, Thomas, Southbridge
McGrath, J. A., & J. H., 18 Masonic St., Northampton
Mague, F. J., West Newton
Martin & Condon, Watertown
Menguale, L. W., Stockbridge
Micheline, A., Reading
Middlesex Construction Co., Medford
Middlesex Construction Co., 7 Water St., Boston
Moynihan, T. A., South Hamilton
Morley-Flatley & Co., Manchester
Morse, R. A., Box 477, Ayer
Mullen, Luke D., 166 Devonshire St., Boston
Nagubach & Son, J., Lawrence
New England Construction Co., 3½ Bellevue St., Worcester
Newell & Co., R. H., Uxbridge
O'Connell & Sons, Daniel, Holyoke
O'Neil, Thos. F., Newburyport
Orlando, Wm., Belchertown
Palmer, John B., 1012 Old South Bldg., Boston
Parsons & Co., Jos. M., Salem
Peer, H. I., Great Barrington
Perine Construction Co., Ashland
Pevear, Everett S., 224 Sea St., East Lynn
Polcaro, John W., Pittsfield
Power Bros., 512 Montello St., Brockton
Pratt, W. R., Dalton
Rafferty & Co., Wm. J., 33 Champney St., South Boston
Rendle, Geo. T., Boston
Rourke, E. J., Abington
Rourke, John J., Lynn
Rowe Construction Co., 1607 Commonwealth Ave., Boston
Saucier, Auguste, South Framingham
Savage, B. E., 30 Dewey St., Worcester
Sears, Wm., East Dennis
Shea & Son, W., West Quincy
Sheehan Co., D. J., Lynn
Simpson Bros. Corporation, Boston
Smith, Edward F., 20 Plymouth St., Worcester
Snow, Chas. W., Truro
Snow & Farrington, Wrentham
Southbridge Engineering & Supply Co., Southbridge
Standard Oil Co., 50 Congress St., Boston
Stuart & Sons Co., T., 22 Pearl St., Newton
Tarbell, Harvey W., Lowell
Thomas & Murphy, Middleboro
Thomas, Herbert L., Centre St., Middleboro
Tomasello, A. G., 69 Gibson St., Boston
Trumbull, C. E., 1121 Tremont Bldg., Boston
Tuttle & Edgerly, Swampscott
Wagenbach & Son, J., Lawrence
Walker, Loring B., Clinton
Ware, John, 18 Ash St., Cambridge
Warren Bros. Co., 142 Berkeley St., Boston
Watkins, James, 10 Fern Ave., Reading
Watkins, James E., Amesbury
Welch, James J., 14 Bridge St., Salem
Wellington, A. J., 235 Franklin St., Boston
Wells, G. Arthur, 137 Vernon St., Worcester
Whipple Co., R. O., 306 Main St., Worcester

Winslow, F. I., 49 City Hall, Boston
Wood Co., H. C., Westfield
Worcester Broken Stone Co., 21 Adams St., Worcester
Young, H. E., Bedford

Michigan

Andre, Cornelius, Grandville
Anderson, Murray, Bay City
Arris, Tom, Concord
Atkinson, R. C., Niles
Bacco, M. J., Iron Mountain
Baker & Sons, James H., Pontiac
Baker, R. D., Detroit
Barnum & Counihan, Iron River
Bean & Jones, Benton Harbor
Benham, W. S., Hastings
Bichler, Nick, Escanaba
Bird, Geo., Fremont
Bishop, C., Reading
Bishopp, S. C., Hillsdale
Blakeslee, C. M., Spring Lake
Blanchard, C. H., Roscommon
Blomgren, J. E., Iron Mountain
Boone Bros., Holland
Boyes & Blandford, Grand Rapids
Boyes, D. W., Grand Rapids
Boyle & Company, D. F., Crystal Falls
Brandback, John, Norway
Bristol, C. F., 226 Travis St., Grand Rapids
Bronson, J. E., Union City
Buckingham, T. H., Stockbridge
Bultema Bros., Grand Rapids
Burton, Steven, Kawkawlin
Bye, Nels, Wallin
Cambrey, Leman A., Pontiac
Campbell, Alex, Bay City
Campbell, Hugh, Bay City
Carbide Company, Sault Ste. Marie
Carlo, Frank, Mt. Clemens
Carpenter & Anderson, Grand Rapids
Carven, Walter, Mason
Coates, George, Munising
Crane, H. A., Midland
Currie, Thos. E., Detroit
Deland & Lynn, Scottville
Deloyia, J., Port Huron
Delta Contracting Co., Escanaba
Detroit Asphalt Paving Co., Detroit
Dyke, Frank, Holland
Erickson & Son, Louis, Ishpeming
Fausey, Amos, Hastings
Fiborn Limestone Co., Sault Ste. Marie
Fogelsonger, D. E., St. Ignace
Fowler, Bert, Tawas City
Fox, A. J., Almont
Freeman, F. H., Engadine
Freeman, Henry, Gould City
Geeck, Andrew, 523 Ada St., Owosso
Globe Construction Co., Kalamazoo
Golden & Boter Transfer Co., Grand Rapids
Good Roads Construction Co., Port Huron
Gredeen, G., Norway
Greenville Gravel Co., Jackson
Hall & Labby, Laurium
Haltz, Ray, Leslie
Harr, C. C., Munith
Harding, Frank, Scottville
Harris, John M., Detroit
Hatch, J. C., Niles
Helfelts Co., J. R., Iron Mountain
Henderson, Tom, Kalamazoo
Hess Brothers, Akron
Heysteck, R., Kalamazoo
Hicks & Barber, Vulcan
Hilding & Rabe, Grand Rapids
Hoag, W. S., Albion
Holmes, Clair, Webberville
Holmes, Herman, Crystal Falls
Howe, John, R. F. D. # 6, Midland
Hutchinson, W. B., Sault Ste. Marie
Hyde, Elonzo, Mason
Isrealson, Paul, Iron Mountain
Jewett, Burt, Cheboygan
Johnson, Fred, Menominee
Johnson, Gust, Wallace
Kloote, John, Grand Rapids
Knapp Co., W. H., Monroe
Kneal, Geo. H., Lansing
Kneal & Ryan, Lansing
Ladue, J. T., 401 Penobscot Bldg., Detroit
Larson & Colborn, Maple Ridge
Lattrel & Co., Marquette
Lennane, W. E., 309 Union Trust Bldg., Detroit
Levick, John, Daggett
Lott, Ed., Iron River
Lowe & Steers, Kalamazoo
Lowery & Manix, Jackson
McBridge, Frank, Corunna
McCracken, W. W., St. Joseph
McCreery, C. W., Box 31, Ovid
McDermott & Cooper, Grand Rapids
McKeesy, Jas., Onondaga
McLead Company, Dan, Garnet
McNicholas, H. M., Marenisco
McNichols, J. E., Marenisco
McRae, A. D., Pentoga
Madison, Chas. E., St. Ignace
Marsman & Green, Grand Rapids
Martin, W. S., Wyandotte
Mercier, J. A., Seminole Ave., Detroit
Michaels, Martin, R.F.D. # 2, Box 52, Deckerville
Mills, Sam, Escanaba
Mitchell, E. C., Jackson
Mitchell George, Dansville
Mitchell, Thos., Battle Creek
Murphy Construction Co., A. J., Port Huron
Murphy, Patrick, Scottville
Myers, Joe, Bessemer
Nebel, Chas. F., Gladstone
Nelson, C. E., Dansville
Nelson, Nels, Norway
Nichols, H. A., Hastings # 3
Noger, R. H., Temperance
Oakley, R. L., 1162 Penobscot Bldg., Detroit
Olds, Orrin, Leslie
Olson & Johnson, Crystal Falls
Olson & Olson, Gladstone
Otis Cement Const. Co., Hammond Bldg., Detroit
Overman, A. T., Cass City
Oxnam & Son, J. W., Ironwood
Parks & Labby, Eagle River
Parr S. L., South Haven
Parr & Wagoner, Plainwell
Patterson, Dan, Hope
Pattison, G. B., 530 Third Ave., Detroit
Peters, William, Wakefield
Peterson & Giling, Sanford
Peterson, Ole, Gladstone
Port Huron Building Co., Port Huron
Porath & Son, Julius, Detroit
Powell & Mitchell, Marquette
Prange, A. H., Grand Rapids
Pratt Construction & Paving Co., 305 State St., St. Joseph
Pripp, A. L., St. Johns
Quinn, J., St. Ignace
Rapin, W. J., Engadine

Rice Construction Co., Wyandotte
Roehm, Paul P., Calumet
Rusche, J. P., Grand Rapids
Ryan, Wm. H., Lansing
Sadler, Clayton, Dansville
Schouldice, Thos., Ironwood
Schultz, Henry., St. Joseph
Shepard, Frank, Ludington
Sherman, Geo. D., 615 Spruce St., Marquette
Sherritt, John, Levering
Shoemaker, F. S., Kalamazoo
Slattery, J. W., North Branch
Small & Son, E. S., Benton Harbor
Smith, Byers & Sparks, Houghton
Stephens & Marks, Topinabee
Sutton, John T., Pompeii, R. F. D. # 1
Snyder & Sons, 726 Cott, Ann Arbor
Tahtinen, E., Ontonagon
Tench & Co., W. E., 36 Winona Ave., Detroit
Thomas, Chas., St. Joseph
Thomas, S. E., Athens
Thompson, E. L., Albion
Thuerkauf, Gustave, Menominee, R. F. D.
Thunder, A. L., 19 East Battle Ave., Battle Creek
Tripp, A. L., St. Johns
Vanderveer, Harry, Grand Rapids
Vanderveer, P., Grand Rapids
Vogel, Oscar, Sterling
Vohlers, Eugene, Ionia
Waber, Lou, Kendall
Walker, Chas. V., Fremont
Ward & Son, Andrew, Oak Glen
Webster, George, Scotts
White Marble Co., Manistique
Williams, C. E., Grand Rapids
Williston Construction Co., Rochester
Zaring, D. L., Three Oaks

Minnesota

Adams, S. H., Ogema
Adolphson, Edw., Aitkin
Albert Lea Construction Co., Albert Lea
Ames, Wylie, Alida
Anderson, Chas., St. Peter
Anderson Co., John, St. James
Aune, John, Mallard
Beebe, H. J., New Auburn
Behrens, Peter, Mahnomen
Bell, Barnum & Borgen, Mahtowa
Benner, Matt, Wabasha
Benson, Sam, Blackduck
Berle, Geo. Henderson
Bittner, C. H., Winona
Blakely Bros., Turtle River
Bodin & Son, August A., Duluth
Boelter, Adolph, Gibbon
Boelter, Julius, Henderson
Bowen, W. L., Lake City
Brasel, James, Green Isle
Brogan, John S., St. Peter
Brown, Charles, Red Wing
Brown, David, Kimball
Brown, J. C., Hibbing
Bueke Bros. & Kreiner, Aitkin
Butler, C. C., Virginia
Carlson Bros., St. Peter
Carter, L. D., Zimmerman
Casey, James, Prior Lake
Cenners, Louis, Cloquet
Chadburne, W. F., Elk River
Chandonnet, Thos., Wauburn
Charland, Geo., Mankato
Chase, John, Chatfield
Christofferson, Christ, Bagley
Clough, D. H., Fidelity Bldg., Duluth
Coffin, A., Litchfield
Collins, Stece, Pillager
Coons Co., E. W., Hibbing
Crommelt, Wm., Pine River
Curtice & Curry, Litchfield
Dahl, E. A., Columbia Bldg., Duluth
Dean, Fred, New Auburn
Derosier, Delore, Ft. Ripley
Devereaux, Wm. T., Park Rapids
Doerr, Henry, Henderson
Donivan, Jas., Green Isle
Durkee, E. E., Cloquet
Eckhart, Joe., Gibbon
Eleffson, Elef, Becker
Elliott, W. H., Plainview
Engstrom & Hasford, Northfield
Everett & Hitch, Brainerd
Falconner, D. M., Aitkin
Falstad & Son, Lake Wilson
Feller, Anton, Dassell
Fielding & Shepley, 216 W. University Ave., St. Paul
Fierer, Geo., Comfrey
Flink, A. B., Center City
Foley, E. H., Zimmerman
Forsman, Lee, Pipestone
Foster, Geo., Kellogg
Fowler & Ray, Mankato
Frye, W. A., Elk River
Fuller, W. L., New Auburn
Fulton, E. R., Marshall
General Contracting Co., Duluth
General Contracting Co., Minneapolis
Gibbs, Clifford, New Auburn
Gilmore, John, Brainerd
Glidden, Sam, Elk River
Gore, E. L., Madelia
Greer, Richard, Zumbro Falls
Hanlon & Oakes, Winona
Hanson, M. C., Coleraine
Hardy, Ed., Dassell
Hart, R. B., Mallard
Hartman, John, Kelliher
Hawk & Hurley, Fulda
Held & Haeberly, New Ulm
Hill, W. H., Bagley
Hoff, Wm., Red Wing
Howe, W. G., Glencoe
Jacobson, I. G., Madison
Jaeger, Richard, Winthrop
Jenson Bros., Clearbrook
Johnson Bros., Mankato
Johnson, Christ, St. Paul
Johnson, E., Watertown
Johnson, J. A., Duluth
Judge, S. T., Elk River
Keeler, A., Anoka
Keough Bros., St. Paul
King, Geo. R., Duluth
Lans, J., Chaska
Larson, L. J., Winthrop
Leatherman, Abe, Plainview
Leefe, Emil, Lake City
Lennon, Wm., Kelliher
Longoor, J. W., Red Wing
Lund, Silas, Onamia
McCann Co., Lawrence, Eveleth
McCave, John, Maseppa
McClure Contracting Co., St. Paul
McCormick, C. H., Wahkon
McDonnell, P., Duluth
McFarland, Robert, Plainview
McKinnon, Naish, Bemidji
McMahanan, M. J., Green Isle
Mason, S. O., Redwood Falls

Miockow, John, Millville
Nagle, Martin, Arlington
Nelson, A. N., Duluth
Nelson Bros. Co., Minneapolis
Newquist, Emil, Carlton
Northern Cement Construction Co., Princeton
North Star Concrete Co., Mankato
Olson Bros., Gonvick
Olson & Johnson, Duluth
Osburne, Frank, Nicollet
Perrine, E. A., Floodwood
Piek & Son, Slayton
Quitberg, A. C., Clearbrook
Read, Ralph, Millville
Resiter, John, Wabasha
Ring, O. J., Gonvick
Robson & Tubbesing, Red Wing
Rogers & McLean, 422 Lyceum Bldg., Duluth
Roland, Wm., Stewart
Schegrud, N. H., Bagley
Schiler, E. S., Cloquet
Schmitt, W. L., Lake City
Schmitz, Barney, Wabasso
Scholberg, Louis, Princeton
Schurhammer, Christ, Wabasha
Schweppe, A. W., St. James
Silvernale & Lindberg, Curry
Soefker, Louis, Arlington
Soule, Bert, Clear Lake
Standard Oil Co., The, Biwabik
Stanley Bros., St. Cloud
Steele, Hugh, Duluth
Stoddard, Chas., Canby
Tews, Albert, Hutchinson
Thomas, F. W., Malaca
Thompson & Anderson, Brainerd
Trondson & Whitting, Blackduck
Turtleloots, M., Elk River
Tyrrell, E. O., Bachus
Vaugh, J. F., Brainerd
Wiceen, Louis, Princeton
Willcuts & Son, Holyoke
Yanley Construction Co., Minneapolis

Mississippi

Box, C. B., Midnight
Callahan, R. A., Potts Camp
Coleman, J. K., Corinth
Coruthers & Co., Booneville
Cunningham & Tate, Brooksville
Dennis, L. B., Lawrence
Edge, Frank, Corinth
Gano, F. A., Jackson
Good Roads Surfacing Co., Meridian
Harvey & Co., F. D., Olive Branch
Harvey & Co., F. D., Starkville
Healy Construction Co., Meridian
Hicks, Hicks & Miller, Pontotoc
Hinds County Construction Co., Jackson
Inland Construction Co., Magnolia
Loper, Floyd, Lake
McTighe-Hughes Co., Hazlehurst
Moore, W. A., Thorn
Morrison Construction Co., Greenwood
Murrill Construction Co., Vicksburg
Owen Construction Co., Brookville
Owens Construction Co., Canton
Owens Construction Co., Madison
Pool & Son, A. P., Meridian
Rinehart, M. J., Corinth
Searcy & Co., R. C., Columbus
Thomason, M. H., Dlo
Wells, J. M., Columbus
Wright, John E., Meridian

Missouri

American Construction Co., New Nelson Bldg., Kansas City
Anderson, C. B., Joplin
Brosnahan, D. T., Kansas City
Brown & Hall Construction Co., 1211 E. 26th St., Kansas City
Buis, J. F., St. Joseph
Byermann Construction Co., 1216 S. Grand Ave., St. Louis
Carmean Bros., Kennett
Carpenter, L., Sedalia
Carr Construction Co., J. T., Liberty
Cavanagh, T. E., St. Louis
Costello, M., 1300 S. 22nd St., St. Joseph
Davidson Construction Co., Kansas City
Eyermann Construction Co., St. Louis
Gidinsky Construction Co., 3419 Kenwood Ave., Kansas City
Gillois, M. E., Monett
Graham Concrete Products Co., Sedalia
Granite Bituminous Paving Co., Railway Exchange Bldg., St. Louis
Harte, W., Kansas City
Hartung, P. A., 200 Bryant Bldg., Kansas City
Hoover Bros. Construction Co., Kansas City
Hueston & Bland Stone Co., Hannibal
Jaicks & Co., Kansas City
Jolly, H. H., Poplar Bluff
Kansas Crusher Co., 501 E. Armour Blvd., Kansas City
Koch, V. E., Joplin
Kost, H., Joplin
Land Construction Co., St. Joseph
Little & Hays, St. Louis
Lynch-McDonald Construction Co., Moberly
McCormick, F. P., Kingsbury Bldg., St. Louis
McKissick, A., Sedalia
McMurray Construction Co., Kansas City
McMurray, J. N., 709 Sharp Bldg., Kansas City
Main, Edgar, Liberty
Meegan, E., 23rd & Hardesty St., Kansas City
Meek, Jr., John F., Chillicothe
Mendee, Joe W., Sedalia
Menefee, J. T., Sedalia
Metropolitan Paving Co., Corby-Forsee Bldg., St. Joseph
Murray & Williams, Sikeston
O'Connor & Son, J., 8000 E. 11th St., Kansas City
Olson Schmidt Construction Co., St. Joseph
Overman, A. T., St. Joseph
Perkinson Bros. Construction Co., St. Louis
Petry, C. T., Fulton
Petry, C. T., Marshall
Pittinger Construction Co., A. H., Kansas City
Ruecking, Frederick, St. Louis
Security Paving Co., Kansas City
Skrainka Construction Co., St. Louis
Spiteaufsky Bros., 26th and Grand Ave., Kansas City
Standard Sidewalk Co., Kansas City
Stiers, Frank A., St. Louis
Stretz & Sons, F., Booneville
Sutton, J. H., Bethany
Turnbull, D. C., Joplin
Tyner Construction Co., E. D., Kansas City
Van Dusen Construction Co., R. W., St. Joseph

Webb-Kunzie Construction Co., St. Louis
Wilcox, E. F., Kansas City
Williams Construction Co., Joplin
Wilson & Yoeman, Monroe City

Montana

Boardman Co., R. M., Butte
Clifton & Appleton, Anaconda
Hager, Ben, Belgrade
Low Miracle Concrete Co., Kalispell
Maguire, J. C., Butte
Malmberg, Alfred, Great Falls
Metcalf, Robert, Butte
Montana Paving Co., Great Falls
Oliver & Brubaker, Glendive
Saner, Fred, Great Falls
Silver & Sons, J. R., Butte
Sweeney, Dan, Helena
Two Miracle Construction Co., Denton

Nebraska

Abel Construction Co., Lincoln
Beebe, John A., Omaha
Burke-Cochrane Construction Co., Lincoln
Condon, Geo. W., 1406 W. O. W. Bldg., Omaha
Condon, Russell, Omaha
Lock Artificial Stone Co., Havelock
Mancini, G., Florence
Monarch Engineering Co., Falls City
National Roofing Co., Omaha
Omaha Structure Steel Co., Omaha
Parks Co., George, 2312 N St., Omaha
Roberts Construction Co., Lincoln
Williams & Son, Omaha

New Hampshire

Bailey, Chas. A., Suncook
Cavanaugh, J. A., Manchester
Jewell, W. W., Gorham
Marcello, Jas., Portsmouth
Nolan, R. E., Box 26, Milton
North East Metal Co., Nashua
Nowell, John C., Franklin
Osgood Construction Co., 25 E. Hollis St., Nashua
Pike & Son, L. M., Laconia
Scrutton, L. E., Portsmouth
Shea, P. D., Portsmouth
Stewart & Snodgrass, Merlin
Tilton, S. D., Woodsville
Woods, Wm., Laconia

New Jersey

Bader, Edw. L., Atlantic City
Bamberger, M. M., 701 N. 16th St., East Orange
Banks, George N., Wildwood
Bennett, G. C., Magnolia Ave., Park Ridge
Bentley, John C., Elizabeth
Bergen County Construction Co., Cliffside Park
Brackett, G. F., Clifton
Burke Co., Joseph F., Plainfield
Cammello & Co., P., Westfield
Celantano, Antonio, Trenton
Clinton Construction Co., 306 Charles St., Hoboken
Cogan, C. J., Bayonne
Cole, W. A., Roselle Park
Copen, R. A., Hoboken
Corson, N. P., 1141 Sycamore St., Camden
Craig & Mulford, Cedarville
Critchfield, W. T. A., 2 Green St., Jersey City
Cullifan & Machanska, Bayonne
Demarest, M. Irving, Searaven
Donovan, Daniel, Bayonne
Doreity, R., Ridge St., Newark
Dougherty, J. B., 89 Mill St., Morristown
Dunigan, Thos. F., Woodbridge
Dyer-Kane Co., 12 Lexington Ave., Passaic
Emmer, R. J., 150 Nesbit St., Weehawken
Faughman, Partick, Elizabeth
Fisher & Son, J. S., Clayton
Fox & Powell, Ocean City
Frech, Geo. M., Somerville
French, Walter S., Moorestown
Geiger Sons, John S., 80 Hartford St., Newark
Gibbs, N. T., Clementine
Gill, A. W., 57 Spring Valley Ave., Hackensack
Gill, A. W., Leonia
Ginder, J., Trenton
Glenfield Construction Co., 141 S. 8th St., Newark
Glennon, John, Boonton
Gray Construction Co., Morristown
Hastings Paving Co., Madison
Hickey & Houghton, Inc., Somerville
Hopper, James G., Ridgewood
Horning, G. J., 516 16th St., West New York
Humphreys, E. C., Hackensack
Husk, Frank, Boonton
Jackson, Wm. & Son, Newark
Jannarone Construction Co., Passaic
Jannarone, Philip & Peter, Newark
Jelin, Abraham, New Brunswick
Jermings Laughlin Co., Asbury Park
Jersey Paving Corporation, Newark
Johnson & Co., Olaf L., Arlington
Kalbach, Stanley M., Wildwood
Kavanaugh Inc., C. T., Bayonne
Kelly-McSeely Co., Camden
Klockner, L. W., Mercerville
Le Compte, John L., Trenton
Lepre & Magniaro, South Orange
Littell & Pfeiffer, Perth Amboy
Logan & Hathaway, Newark
Logan, Wm. S., 9 Clinton St., Newark
McCabe Bros., Bayonne
McMahon Construction Co., Newark
McGovern, J. F., New Brunswick
Manson & Son, T., Monmouth St., Red Bank
Marsellis, A. S., Upper Montclair
Martin, Herman, Leonia
Miles, Tigh & Co., Phillipsburg
Miles, Tigh & Co., Newark
Montgomery, R. A., 26 Exchange Place, Lambertville
Moon, W. R., Far Hills
Newark Blue Stone Co., Newark
Newark Paving Co., Newark
Newton Paving Co., Trenton
Northern Construction Co., 665 Broad St., Newark
O'Connell, Maurice J., 135 Union St., Hackensack
O'Gara & McGuire, Newark
O'Hagan, Michael, Phillipsburg
O'Neil, J. J., Elizabeth
O'Reilly Contracting Co., Jersey City
Oliver, H. V., 21 Liberty St., New Brunswick
Osborne & Marsilles Co., Upper Montclair
Phillipsburg Supply Co., Phillipsburg
Potts, J. J., Elizabeth
Ramsay, Oliver W., Perth Amboy

Richards & Gaston, Newton
Riddle, T. H., New Brunswick
Salmon Bros., Hackettstown
Salmon Bros., Netoong
Salott, Conrad, New Brunswick
Sampson, Samuel, Elizabeth
Sands-Kline Co., Morristown
Scott Contracting Co., H. N., Craubury
Sellico, Jos., Church St., South Orange
Shanley Co., J. F., Newark
Sharp, Chas. A., Madison
Sowerbutt & Harrop, Paterson
Sproul Construction Co., H. B., Westfield
Staknevitch, A. J., Bloomfield
Standard Bitulithic Co., Newark
Sutton & Corson Co., Ocean City
Telfer, Peter, Boonton
Ten Broeck-Morse Eddy Co., Bayonne
Utility Construction Co., New Brunswick
Van Keuren Contracting Co., Prior St., Jersey City
Viscount, T., Elizabeth
Ward, Aaron, Camden
Wehrle, Jr., John, Hackensack
Weldon Construction Co., Rahway
Weldon Construction Co., Westfield
Winans Co., C. H., 207 Broad St., Elizabeth

New York

Adirondack Construction Co., Waterford
Aetna Engineering & Contracting Co., Herkimer
Aikenhead, Bailey & Donaldson, 331 Powers Bldg., Rochester
Albany Construction Co., The, Albany
Almahar Construction Co., 100 State St., Albany
Anderson, Jr., John, Newcomb
Armstrong & Trowbridge, Middletown
Arnold & Shearer, Box 267, Albany
Asphalt Construction Co., Madison Ave. and 137th St., New York
Atlanta Constructing Co., Atlanta
Baird Contracting Co., M., New York
Baker, E. Brown, Herkimer
Baker, E. D., 27 Broome St., Binghamton
Banebrick, John, Gasport
Banher, Albert M., Gloversville
Bardol, F. V. E., Buffalo
Barker, Albert M., Johnstown
Barker & Varney, Batavia
Beebe Bros., Keene Valley
Begent, Fred W., Newport
Belmar Construction Co., Troy
Benson & Co., S. T., Falconer
Beskin, Samuel, Bestman St., Fishkill Lodge
Bison City Engineering & Contracting Co., Buffalo
Bluff Point Stone Co., Plattsburg
Bohl & Goets, Albany
Bonn, Samuel, Syracuse
Borough Asphalt Co., 1301 Metropolitan Ave., Brooklyn
Boynton, Kellogg, Keesville
Bracalello, Frank, P. O. Bldg., Scarsdale
Bradley & McGreevey, Elmira
Brady-Oltarsh Construction Co., New York City
Brancaccio & Co., Inc., 348 E. 15th St., New York
Brayer Bros., 2 Smith Block, Auburn
Breese Construction Co., 100 Lake St., Elmira
Brennan, J. W., Geneva
Brennan, Wm., Herkimer
Brewer, A. C., Oriskany Falls
Bridgeport Construction Co., Poughkeepsie
Brooke & Julian, Powers Bldg., Rochester
Brooklyn Alcatray Asphalt Co., Brooklyn
Brotsch, Jr., F. A., Triangle Bldg., Rochester
Brotsch, L. H., Rochester
Brown & Lowe Co., 111 Foster Ave., Schenectady
Brown, E. H., Hempstead
Brown, Thomas C., Schenectady
Buckley Construction Co., Plattsburg
Buffalo Structural Steel Co., Buffalo
Bunbda & Washington, Monticello
Bunce & Co., H. E., 135 Fulton St., Olean
Burchill, John R., Syracuse
Burgard Co., Henry P., 275 Lathrop St., Buffalo
Burham & Rose, Albany
Burke, Jos. F., Plainfield
Burnham & Co., W. A., Glens Falls
Burns Co., W. J., 421 Bastable Bldg., Syracuse
Burns & McCowville, Ogdensburg
Burns Bros. & Haley, Savings Bank Bldg., Watertown
Burnside Contracting Co., New York City
Busch & Percival, 523 Brisbane Bldg., Buffalo
Bushley, Frank A., Norwich
Cairnie-St. George Co., Inc., Albany
Calahone, Jas. P., Jamestown
Campion, Wm. F., Albany
Canney, A. W., Croton-on-Hudson
Capel, Inc., Joseph, Astoria
Catskill Supply Co., Catskill
Central City Paving Co., 213 Kirk Bldg., Syracuse
Chambers, George, Rochester
Chambers & Barnes, Rochester
Chambers & Truesdale, 315 Powers Bldg., Rochester
Chenango Construction Co., Albany
Ciarcia, Jas., Mt. Vernon
Clancey & Van Alst, Long Island City
Cleveland, L. B., Watertown
Coddington, S. Read, Niagara Falls
Coe & Blanchard, Suffern
Cohen, Frank L., 49 Niagara St., Buffalo
Colamseo, Antonio, Hudson
Cold Spring Construction Co., Buffalo
Conley, F. D., 338 E. State St., Ithaca
Conley, Patrick B., Ithaca
Connolly Co., Peter F., Horseheads
Connolly Co., P. F., Chemung
Connors & Gallavan, Elmira
Connors, Jos. H., Fulton
Conroy & Nixdorf, 25 William St., Oneida
Consalus, John E., 50 State St., Albany
Continental Public Works, 2 Rector St., New York
Conway, James, Plattsburg
Cooper, H. B., 326 State St., Albany
Cooper Co., R. D., 513 Main St., Little Falls
Cooper, Snell Co., Little Falls
Corbin Co., Inc., H. K., 30 Church St., New York
Corliss Construction Co., Laundry Pl., Troy
Couchy & Darling, Dolgeville
Coughlin & Lowman, N., Elmira
County Construction Co., Troy
Cowhig, W. J., Albany
Cox Contracting Co., P. T., Manhattan
Cramer, Peter, 114 E. 52nd St., New York City
Cramond Construction Corp., Albany

Crampton Bros., Great Neck
Crane, Charles W., 17 Battery Pl., New York
Crim & Gray, Jordanville
Culker Co., J. A., Oswego
Cuozzo, Jas. L., Yonkers
Dale Engineering Co., Utica
Daly & Merritt, Portchester
Daniels Co., O., Woolworth Bldg., New York
Defiance Corpn., Ticonderoga
DeGraff & Hogeboom, 130 Fair St., Kingston
Delaware Construction Co., Sidney
Delmar Contracting Co., Troy
Dickison, G. B., Syracuse
Dickinson & Mongano, Silver Creek
Di Menna & Del Balso, New York City
Dimenna, J., 2435 Southern Blvd., New York
Doherty, C. J., New York City
Dolan, John F., 50 Church St., New York
Dollard, M. F., Rensselaer
Dollard, M. F., Albany
Dollard & Heeran, 118 Van Wert St., Albany
Donovan, J. E., 2205 Richmond Terrace, New York
Donovan, John F., Saugerties
Dorpian City Construction Co., 313 Congress St., Schenectady
Dower, John B., Ballston Spa
Doyle & Co., E. J., 83 State St., Albany
Doyle, John, Albany
Dugan Co., Inc., John P., Amsterdam
Dugan Co., John P., Gloversville
Dunbar Construction Co., 440 N. 68th St., New York City
Dunkirk Construction Co., 114 Eagle St., Dunkirk
Eagle Paving Co., Syracuse
Eastchester Contracting Co., Tuckahoe
Eastern Asphalt Co., Mt. Vernon
Eastover Construction Co., Inc., Utica
Edgecomb Bros., Binghamton
Edgecomb, Woodruff, Eastbranch
Eggleston, E. T., Yonkers
Elbech, E. L., White Plains
Elmere & Hamilton Construction Co., McDonald Bldg., Schenectady
Erie Construction Co., D. S., Morgan Bldg., Buffalo
Falk & Menzien, 6 S. Division St., Buffalo
Fallkill Construction Co., Poughkeepsie
Falls Bros. & Fletcher, 338 State St., Rochester
Fearl, H. W., Potsdam
Federal Asphalt Corpn., New York City
Felton, Wm. F., Buffalo
Field, Wm. T., Watertown
Fitzgerald, Thos., Fredonia
Fitzgerald, W. J., 547 W. 45th St., New York
Fitzwater & Terry, Waterville
Flood & Van Wirt, Hudson Falls
Flynn, Alfred H., Albany
Flynn, John W., Waterford
Foote, Frank J., Nunda
Foote, Frank M., Arcade
Fort Schuyler Construction Co., Utica
Fort Schuyler Construction Co., Oneida
Fowler Construction Co., F. G., Mt. Kisco
Fox, W. G., Saratoga Springs
Fox, W. J., Oramel
Franklin Contracting Co., 52 Vanderbilt Ave., New York
Fredella, Jos., Glens Falls
Friedman, L. H., 31 Union Sq., Manhattan
Friedrich Co., J., Rochester
Frost, Willis L., Watkins
Fulton Engineering Co. Inc., Albany
Fulton Engineering Co. Inc., Walton
Gaffey, Albert, 260 Jamaica Ave., Syracuse
Gaffney & Sons, B., Saratoga
Galgano Co., New Rochelle
Gallagher, Frank J., 490 Park Place, Brooklyn
Gallagher Co., John F., Kingston
Gallo, Frank, Herkimer
Garfano, James, S. Third Ave., Mt. Vernon
German Rock Asphalt, Buffalo
Gibbons & Co., Geo. B., New York
Gifford Construction Co., Jamaica
Gill Co., T. H., Binghamton
Gill, Thos. H., Pine Valley
Gipp Co., Louis H., 94 Claremont Ave., Buffalo
Gleason Co., M. J., Syracuse
Gordon, John H., Albany
Gradwohl Engineering & Contracting Co., 101 Park Ave., Manhattan
Grady & Co., Thos., Butler Bldg., Rochester
Grauer, A., 120 Broadway, New York
Greece Construction Co., 718 Chamber of Commerce Bldg., Rochester
Green & Miller, Schenectady
Greenfield Construction Co., 86 Main St., Hornell
Grimm Construction Co., 460 Herold Ave., Brooklyn
Guinan Contracting Co., J. J., 777 Fulton St., New York City
Gullotte, Frank, Schenectady
Gurnett, John W., Watkins
Hagaman Co., F. L., Rochester
Hagaman & White, 16 State St., Rochester
Hagaman, Miller & Hagaman, 688 Clinton Ave., Rochester
Haight, A. B., Oxford
Hailes, Jr., Theodore C., 86 State St., Albany
Hallinan Bros., Little Falls
Hallock & Angle, Newburgh
Hamilton, F. W., 238 Spencer St., Rochester
Hammond-Tracey Construction Co., Inc., Middleport
Haneboldt & Washington, Monticello
Haney, Charles E., Camillus
Harlem Contracting Co., New York City
Harper & Higginson, Inc., Newburgh
Harper, Jova & Kehoe, 62 Second St., Newburgh
Harradine Bros., Spencerport
Harrison Engineering & Construction Co., Buffalo
Harrison, H. B., Buffalo
Hartney, Edw., Modena
Hasard, Wm., Trumansburg
Hastings Pavement Co., 25 Broad St., Manhattan
Heisler, Jos., Schenectady
Heling Bros., Lindenhurst
Hendrickson-McCabe Construction Co., The, Syracuse
Henson, Robert W., Pullney St., Geneva
Herlihy Construction Co., 16 Bridge St., Glens Falls
Hill & Co., W. F., Fulton
Hillson Bros., Kinderhook
Hinds, Wm. F., De Ruyter
Hodge & Co., C. D., Watertown
Holler, J. M., Albany
Hookway, C. T., Syracuse
Hopkins, Richard, 824 Second Ave., Troy
Hotchkins, H. A., Jamestown
Hucknall Construction Co., Albion
Hughes & Co., J. A., Jamestown
Hull, Seneca P., Cortland
Hurley & Lyne, 86 Temple St., Fredonia
Huston, T. L., New York City

Hyde, John R., Rome, R. F. D. No. 1.
Jackmann, Edw., White Plains
Jackson Bros., Cuddebackville
Jamestown Construction Co., Jamestown
Johnson Construction Co., John, Buffalo
Johnson & Co., John E., Buffalo
Johnson Sons, Joseph, 455 Broadway, West New Brighton
Johnston, Jas. W., 5014 Bleecker St., Utica
Jones, Clyde G., Jamestown
Jova, Inc., John A., Newburgh
Kalteaux Co., Frank, Schenectady
Kane Co., J. P., 103 Park Ave., Manhattan
Kantrowitz, Morris, Albany
Karr, Thos. H., 714 Fulton St., Troy
Keeseville Rd. Co., Inc., Keeseville
Kelly, Leo. E., Brooklyn
Kelton, R. A., Albany
Kennedy, P. J., Utica
Kennedy Construction Co., 534 Broadway, Albany
Kerwin Construction Co., 27 Howard St., Albany
Kimmey, Wm. R., Albany
Knapp, R. W., Mooers
Lake Shore Construction Co., Dunkirk
Lamb, Richard, 90 West St., New York
Landel, Carlisle O., Tonawanda
Landel, John W., Tonawanda
Lang & Horton, Schuylerville
Langan Construction Corpn., Albany
La Porte & Hall, Mechanicville
Law, Wm. J., Herkimer
Lawrence Construction Co., Albany
Lawton, W. L., Glens Falls
Leopold & Co., Inc., J., Woolworth Bldg., Manhattan
Lorintine & Son, A. F., Plattsburg
Lynden Construction Corpn., Albany
Lyne, John J., Binghamton
McCabe Construction Co., Wm. F., White Plains
McCarey, Bernard, S., Rome
McCarthy & Wall, Mt. Morris
McComb, Charles O., Syracuse
McConville, A. J., Ogdensburg
McDonald Construction Co., Wm. P., Albany
McDonald Construction Co., Wm. P., Mt. Vernon
McEvoy, Geo. H., Creek Locks
McGreevey, McGuigan & Baum, Elmira
McGuire & Fahy, Hornell
McLoughlin & Burchill, 322 Bastable Bldg., Syracuse
McMahon & Farrington, Waterloo
McMahon & Farrington, Binghamton
McMahon & Fell, 1041 Cleveland Ave., Niagara Falls
McNamara, James, 425 Robin St., Dunkirk
Madden, Wm. H., Rochester
Mahoney, Thomas, 51 Falkner St., Jamestown
Mahoney & Swanson, 225 Fortcoyne St., Jamestown
Malatesta, J. B., New York City
Malloy, J. J., 1404 Albany St., Schenectady
Malone, Frank, Syracuse
Maltby, Geo. L., Jamestown
Manion, Jos. W., Albany
Martin, Thos. J., Beacon
Mascio, Angelo, 2137 Arthur Ave., New York
Mathusa, C. S., Albany
Mecca Construction Co., Inc., Morristown
Melius, L. L., 2306 8th Ave., New York City
Merone & Cortesi, Mt. Vernon
Merritt Construction Co., Tuckahoe
Mesler, Geo., Liberty
Miller Bros., Schenectady
Miller & Knickenberg, 702 Michigan St., Buffalo
Mitchell, Wilson Co., Niagara Falls
Mondo Construction Co., Inc., Syracuse
Monroe Roads Co., Pittsford
Morano, Ben, White Plains
Morrison & Quinn, Inc., Rochester
Mosier & Summers, 1266 Seneca St., Buffalo
Mott, Daniel L., Utica
Moynahan Co., J. D., Mohawk
Mulderry Bros., Albany
Mullen, Henry J., 289 Fulton St., Jamaica
Mumm, Fred J., 176 Best St., Buffalo
Mumm Contracting Co., L. J., Buffalo
Murphy, Harry, Albany
Murphy, John A. & B. Thos., Cobleskill
Murray Construction Co., Martin, 14th and Fulton Sts., Troy
Murray, Patrick M., Cutler Bldg., Rochester
Murray, Thos. F., Le Roy
Nash & Griffin, Norwich
Nelson & Co., John H., Herkimer
Newman, Henry, 215 Montague St., Brooklyn
Newport Construction Co., Newport
Niagara Construction Co., 263 Richmond Ave., Buffalo
Norclone, Frank, Mt. Vernon
O'Brien, Michael, Cortland
O'Brien, Thos., Watertown
O'Hern, Thos., Yonkers
O Neil, John T., Troy
Orange County Road Construction Co., Central Valley
Osborne, A. D., Binghamton
Oswego Construction Co., S. 1st St., Fulton
Paddock & Williams, Oneida
Paddleford & King, Sherburne
Pathfinder Construction Co., Fulton
Peckham Construction Co., Buffalo
Peters Co., N. D., Utica
Petrillo Bros., Mt. Vernon
Petrossi, A., Rochester
Phelan & Sullivan, Utica
Phoenix Sand & Gravel Co., 17 State St. New York City
Piro, James, Mt. Vernon
Potter, S. J., Ticonderoga
Rappleyea, Geo. D., Prattsville
Reardon, C. J., 114 Warren St., Glens Falls
Reynolds, C. W., New York City
Rhody & Clawson, Albion
Rhodey, F. H., Albion
Ribstein-Holter Construction Co., Rochester
Rice, C. E., Weedsport
Richards, David, White Plains
Richmond, J. L., Hinkley
Roberts, Harry W., 13 Broad St., Utica
Rochester Vulcanite Pavement Co., Rochester
Rock-Griffin Co., Winthrop
Rock-Griffin Co., Massena
Rockwood, A. J., 407 Cutler Bldg., Rochester
Roeh & Griffin Co., Watertown
Rosenthal Engineering & Contracting Co. Brooklyn
Rossney Construction Co., Buffalo
Ruddy & Saunders Co., Troy
Russo, Parkes, 119 S. Warren St., Hudson
Ryan & Yale, Brewsters
St. Lawrence Construction Co., Inc., Albany
St. Regis Construction Co., Albany
Santanoni Construction Co., Newcomb

Saptienza, James V., 19 Georgia St., Buffalo
Schaupp, H. A., Guilderland
Schneider, F., 1531 Westchester Ave., New York
Schoentag, C. T., Saugerties
Schroeder-Hicks Construction Co., Mercantile Bldg., Rochester
Schults, J. B., Fredonia
Schults, Paul, Albany
Schunnemunk Construction Co., Highland Mills
Schuyler Construction Co., Bert, Utica
Seaman, Thos. H., Poughkeepsie
Semper Bros., Watertown
Semper, Charles R., Syracuse
Service & Mackey, Youngstown
Seymour, A. A., Little Falls
Shaffer Co., Inc., W. B., 303 Fifth Ave., New York
Shaughnessey & Co., T. T., 372 Broadway, Albany
Shaw, Jr., Arthur J., Batavia
Shaw & Co., Walter F., Jamestown
Sherman Contracting Co., Inc., Ononeta
Sherman Contracting Co., Gloversville
Shipman & Lincoln, Gowanda
Shutt, Albert M., Sidney
Sicilian Asphalt Paving Co., 41 Park Row, New York
Sickles, E. S., New Baltimore
Sieling, Louis J., 171 Madison Ave., New York
Smith Bros., Construction Co., Pelham
Smith, F. V., New York City
Smith, Robt. W., 136 Liberty St., New York
Snead & Wilson, Brown Station
Snell & Co., D. I., Canajoharie
Snell, L. J., Little Falls
Snyder, Carl G., Amsterdam
Soper & Son, Smith, Seneca Falls
Spellman-Oliver Co., Chautauqua
Spellman-Oliver Co., Mooers
Spencer, W. B., 2 Rector St., New York
Sproul Construction Co., Inc., H. B., Peekskill
Spuyten Duyril Construction Co., 271 W. 125th St., New York City
Stabbell & Co., J. F., Buffalo
Standard Oil Co., 26 Broadway, New York
Starr Contracting Co., Frederick, 604 W. 47th St., New York City
State Highway Construction Co., 50 State St., Albany
Staub, Michael, Mamroneck
Stento, Frank, Binghamton
Stephens, G. C., Albany
Steuben Construction Co., Hornell
Stewart & Co., James, 30 Church St., New York City
Sullivan Construction Co., Syracuse
Styring, Edwin, Theresa
Suffock Construction Co., Huntington
Sullivan, John D., Keeseville
Swarts, Wm. J., Newark
Sweeney & Boland, Rochester
Taylor & Ousterhoudt, Olean
Thayer, W. T., Chateaugay
Tomkins, Calvin, 17 Battery Pl., Manhattan
Tresley, Wm. F., 18 E. 119th St., New York
Trey & Mack, 239 N. Union St., Olean
Troin, James V., Mt. Vernon
Trombly & Eldert, 36 N. Washington St., Jamaica
Tryon, C. W., Poland
Tyne-Willey Co., Binghamton
Ulrich & Persicano, Brooklyn
Underhill & Son, E. M., Glen Cove
Union Paving Co., Schenectady
United Construction Co., Albany
Upper Hudson Stone Co., 26 Cortland St., Manhattan
Uvalde Asphalt Paving Co., 1 Broadway, Manhattan
Vanderbilt, C., 24 E. Elizabeth St., West New Brighton
Van Horn, Frank D., New York City
Van Wagonon, S. B., Rondout
Veder Construction Co., The, Delevan
Waldon & Mead, Plattsburg
Walker, H. W., Jamestown
Walker, Joseph, 44 State St., Albany
Wallace, Ray C., Herkimer
Walsh, Edward, 137 Ferry St., Troy
Walsh, Jas. E., Mechanicsville
Ward & Tully, Inc., Brooklyn
Ward, Owen, Johnstown
Warner-Quinlan Asphalt Co., Syracuse
Warsaw Construction Co., The, Warsaw
Webster, W. E., Buffalo
Weed & Walsh, Mechanicsville
Weidman, J. H., Syracuse
Welch Co., Clarence, Gloversville
Wells, Boughton & Co., Troy
Wells, E. H., Savannah
White & Colligan, Purchase
Whitmore, Rauber & Vicinnes, 279 South Ave., Rochester
Wideman, John H., Syracuse
Wilkes-Casey Engineering & Contractin Co., New Rochelle
Willey, A. L., Binghamton
Williamson, H., Eastwood
Wilson, Busch & Percival, Kenmore
Wiltsie & Rigney, Rensselaer
Winston & Co., 290 Broadway, New York
Winston Co., Brown Station
Wood & Tompkins, Hilton
Wright, Rollin E., Cortland
Young, Andrus D., 121 Putnam Ave., Brooklyn
Young, N. E., Binghamton
Young, Nathan E., Cooks Falls
Zimmer, Jr., Thos., J., Poughkeepsie

North Carolina

Bennett Co., D. A., Winnabow
Boon, J. W., Newport
Brown Granite Co., Albert, Asheville
Cornwell & Co., Hickory
Fanning, Cowan & Oates, Asheville
Hudson Paving Co., R. M., Concord
Johnson, Porter & Peck, Charlotte
Lassiter & Co., R. G., Oxford
McCrady Engineering Co., W. S., Morganton
Minus, P. S., Asheville
Moore & Abeel, Wilmington
Potts, J. T., Greensboro
Stevens, R. C., Asheville

North Dakota

Bulbranson, O., Ambrose
Burrows, H. B., Crosby
Grand Forks Concrete Co., Grand Forks
Smith, C. D., Minot

Ohio

Acton, J. W., Vaughnsville
Adams Bros. Contracting Co., Cambridge
Adams Bros. Contracting Co., Zanesville

Allen, L. L., Larue
Andrews Asphalt Paving Co., Hamilton
Arthur & West, Jackson
Baker Construction Co., Quarry Rd., Columbus
Baldwin Bros. Co., Cleveland
Balts, H. J., Norwalk
Barnett & Leach, New London
Barrett Company, 1317 Illuminating Bldg., Cleveland
Barthlow & Son, Logan
Bartling, Wm., Rockford
Bates, H. M., S. 3rd St., Steubenville
Bauer, Geo., Pomeroy
Baum, O. H., Upper Sandusky
Baun & Ankney, Upper Sandusky
Bean & Co., Highland
Bigler Bros., Middletown
Billing Artificial Stone Co., Cincinnati
Blodgett & Mullen, Lima
Bolin, B. F., Newark
Bowen, Geo., Pomeroy
Bowsher, T. E., Wapakoneta
Brehm, A. J., Cincinnati
Brewer, Tomlinson & Brewer, Chillicothe
Brock Bros., Luckey
Brookville Bridge Co., Brookville
Brough, C. E., Luckey
Buck, J., Chardon
Buckeye Engineering Co., Norwalk
Burnett & Christian, Rockford
Burnett, R. P., 527 Society for Savings Bldg., Cleveland
Burns & Co., A. W., Columbus
Butler, J. W., Cincinnati
Byrnes, Jos. A., 1209 Piedmont St., Cincinnati
Capital Construction Co., Columbus
Carey & McElroy ,Ada
Carey, J. W., Ada
Cash, R. E., 409 Lincoln Inn Court, Cincinnati
Central Construction Co., Fremont
Central States Construction Co., Columbus
Champion Bridge Co., The, Wilmington
Cisler & Morse, Marietta
Citizens Road Preserving Co., Cincinnati
Clark, M. F., Youngstown
Cleveland Paving & Construction Co., 1128 Citizens Bldg., Cleveland
Cleveland-Trinidad Paving Co., 420 Lakeside Ave., N. E., Cleveland
Clifford & Shannafelt, Martins Ferry
Comisky, James, 370 Cluster Ave., Youngstown
Compher, F. O., Gilmore
Connelly & Son, M. P., Youngstown
Coon & Savage, Swanton
Corl, H., Canton
Crawford & Little, Elyria
Creager & Co., Hamler
Culberston, H. E., Citizens Bldg., Cleveland
Curry & Co., H. W., Eaton
Curtis & Thoenen, Greenville
Daley Bros. Construction Co., Bolivar
Davidson, J. M., Akron
Day & Co., J. M. Peebles
Dayton Construction Co., Dayton
Deets, P. M., Millersburg
Deitrick & Gabriel, A. P., Bellefontaine
De Jute, James, Niles
Dell & Serafino, Youngstown
Dempsey, J., Norwood
Denner, William, Berea
Dennis, C. E., Tiffin
Devine & Co., J. C., Alliance
Diorio, E., Youngstown
Doan & Laugendorfer, Toledo
Doherty, Jr., J., Cincinnati
Doolittle & Garland, Kent
Downs Construction Co., Canton
Downs & Co., E. S., Toledo
Duffenbacher, Wm. J., 2036 Wooster St., Massillon
Eddy, B. F. & W. A., Trimble
Edgington, C., Arlington
Elyria Constructing Co., Elyria
Emery & Sons, E., Zanesville
Enck, Henry, 539 W. Market St., Lima
Evans Bros., Hubbard
Evans, Thomas, 3515 Mooney Ave., Cincinnati
Falls Construction Co., 306 American Trust Bldg., Cleveland
Farrell Engineering & Construction Co., Cleveland
Federal Asphalt Paving Co., Hamilton
Fitzgerald, T. P., Ashtabula
Foley, D. P., Luray and Park Ave., Cincinnati
Foos, B. W., Fremont
Forest Construction Co., Forest
Forman & Putnam, Marietta
Frank, C. H., E. Deshler Ave., Columbus
Freshwater & Sons Co., 9703 Madison Ave., Cleveland
Frunch, A. J., Wakeman
Funke, John, Cincinnati
Gaghan, McGhee & Strohl, Custer
Geigele & Son, G., Columbus
Geiger & Fink, Dayton
Gessner & Cothrell, Toledo
Gilmore Bros., New Lexington
Gould & Maybach, 823 E. 150th St., Cleveland
Graham, A. A., Mt. Vernon
Graham & Kinnear, Columbus
Graham Co., J. M., Peebles
Graham, W. S., Waynesville
Graves, Barrett & Leech, New London
Gray Brothers., Bowling Green
Green & Getman, Kent
Green & Getman, Ravenna
Greenville Gravel Co., Greenville
Gruber, T. A., Mansfield
Hamilton & Burger, Eldorado
Hampshire & Wilson, Circleville
Hanlon Construction Co., Cincinnati
Harper & Stuart, Bremen
Harris & Tousey, Toledo
Hart & Kemp, Elyria
Harving & Son, G. B., Mansfield
Heffner & Son, G. H., Celina
Henkel & Sullivan, Cincinnati
Hennessey Bros., Piqua
Hepburn & McClain, Lisbon
Herring & Son, G. B., 1039 Drecel Ave., Cleveland
Herring & Son, Geo. B., Mansfield
Heyman & Heyman, Bellevue
Highway Construction Co., Elyria
Highway Improvement Co., Fremont
Hill & Hill, Elyria
Holmes Construction Co., The, Millersburg
Hoolihan Co., C., Dayton
Horan, H. J., 420 Valentine Bldg., Toledo
Howell, W. I., Wapakoneta
Huffman, Ackerman & Gillespie, Berlin Heights
Hunt & Son, Kent
Huston & Henderson, Coshocton
Jameson & Bloser, Lima

Jennison-Wright Co., 312-15 Huron St., Toledo
Johnson & Ritz, Napoleon
Johnson, John, Union
Johnson, Van Wagner & Johnson, Tontogany
Junk, Osther M., Chillicothe
Justus, Wesley E., Circleville
Karsch, J. W., Celina
Keener & King, Jackson
Kelly Construction Co., Bryan
Kelly, W. D., Canton
Kennedy-Warner Co., Medina
Keuhler, W. J., McArthur
King, John E., Tiffin
Kirchner Construction Co., Cincinnati
Kisener & Sons, S. C., Delaware
Kitterman & Blackburn, Mark Center
Knepper, B. D., Tiffin
Kroft Bros., Ada
Krout & Gilmer, D. B., Mt. Blanchard
Kuhl Artificial Stone Co., Charles, Cincinnati
Kuhner & King, Jackson
Kuhner, Kuhner & King, McArthur
Latshaw & Stinchcomb, Fostoria
Lee, Griggs & Andrew, Millersburg
Lewis & Co., E. C., Lima
Liggett, J. P., Hopedale
Logue, H. C., Amelia
Lowenshon, David, 10402 Parkgate Avenue, Cleveland
Lunsford, Basil, Pedro
McAlonan Bros., Akron
McArthur & Fox, Belle Center
McCann & McCann, Columbus
McCann & Son, J. C., Columbus
McCarey & Starks, Xenia
McCormack & Sons, John, Erie
McDermitt & Hannan, Niles
McDowell, J. W., Ottawa
McHugh Bros., 8819 Yale Ave., Cleveland
McIllfresh, Danford & Glover, Caldwell
McKim, T. J., Marietta
McShafrey & Son, E., Akron
Mahl Bros., N. 5th St., Ironton
Mahoney Contracting Co., Youngstown
Manning, H., New Weston
Manson Co., Cleveland
Mants, H. Frank, Marietta
Marriner & Sons, Athens
Martt, W. H., Gallipolis
Maumanx & Ross, Pomeroy
Meahl, Carl & George, Ironton
Meeker, Ellsworth, Bethel
Mercer, Geo. E., Pemberville
Mercer, G. E., Scotch Ridge
Miller, Curtis, Dayton
Miller, C. J., Chamber of Commerce Bldg., Toledo
Miller, Geo. S., Medina
Miller, Wm., Gallipolis
Miller, W. N., St. Clairsville
Mings & Staten, Eaton
Modern Construction Co., Fremont
Monroe & Son, S., Portsmouth
Morgan, A. C., Cadiz
Morrow, H. P., Hillsboro
Mueller Construction Co., Columbus
Muldon & Bergen, Genoa
Mumaf & Ross, Pomeroy
Murdock, George, Norwood
Murphy, J. H., Burgoon
Murray, E. D., Urbana
Mustard, J. R., Ada
Nagel, Fred, Urbana
National Lime & Stone Co., The, Carey
Neipfoot, H. J., Elyria
Norman & Son, Dover
Oatley & Ensign, Cortland
O'Briant & Gregg, Marysville
Odell, Alfred, Fort Recovery
Ohio Concrete Supply Co., Fremont
Ohio Engineering Co., Lorain
Ohio Marble Co., Piqua
Olson Construction Co., Victor, Youngstown
Onkst & Son, D. A., Dayton
O'Sullivan, M. F., Toledo
Pace Bros. Co., Lakewood
Palmet, S. A., Marietta
Parshall, E., Akron
Parshall & Son, S. W., 50 Fay St., Akron
Patterson, B. F., 1214 Niel Ave., Columbus
Patton & Faust, Lowell
Paxton, J. D., Salem
Payne Engineering Co., Akron
Payne, W. F., Springfield
Pearson & Welsh, Fremont
Peters & Baird, Wadsworth
Peters Bros. & Co., Toledo
Phillips, D. A., Ashland
Pickering, Lewis, Bellefontaine
Praechter, P., 2935 Gerard Ave., Cincinnati
Public Construction Co., Elyria
Pugh, A. G., Union National Bank Bldg., Columbus
Putnam, Sol, Van Wert
Quigley & Meeker, Youngstown
Quill, M. F., Vine and Canal St., Cincinnati
Radebaugh, E. C., Logan
Radabaugh, J. L., Montgomery
Reichelderfer Bros., Circleville
Rennick, Harness, Williamsport
Rieley Bros., Arcade Bldg., Cleveland
Rinehart Bros., East Liverpool
Ringwald & Son, W. H., Chillicothe
Roach, R. C., Defiance
Roehl Bros., Cleveland
Rousch, R. C., Canton
Ruebel Construction Co., John, Cincinnati
Runk & Runk, Cincinnati
Russell-Jennsion Co., Huron St., Toledo
Ryan, C. W., Maumee
Ryan, E., Springfield
Scott, C. W., Hillsboro
Seiple & Wolfe, Youngstown
Seuter, S. S., Canton
Schilling Construction Co., Youngstown
Semler, J., Findlay
Shafer, D. G., Caldwell
Shafer, Oliver G., Caldwell
Shannon, John J., Piqua
Sheppard Bros. & Taylor, Kenton
Shoemaker, Clifford, 1136 Walter St., Columbus
Skeels, John, Canton
Smith Construction Co., Youngstown
Smith, O. L., Leipsic
Snouffer, J. M., Columbus
Solomon Co., H. L., Lima
Souder & Peter, Fostoria
Sousley & Botkins, Ada
Spangler & Erman, Evansport
Spencer, J. K., Oregonia
Springer & Rogers, New Philadelphia
Sproul, George & Murphy, J. H., Burgoon
Sprout, G. W., Burgoon
Staab, C., Reading
Stolts, Chris., Bellevue
Stone, R., Lima
Stordbeck Bros., Middletown
Strack, Thomas P., 31 Goodall Bldg., Cincinnati

Strayer, A. L., Liberty Center
Streicher Co., H. P., Toledo
Strodbeck Bros., Middletown
Stroman & Burke, 9 Public sq., Cleveland
Swank & McIntire, New Lexington
Swingle Construction Co., J. A., Zanesville
Tarritan & Erman, Evansport
Tarvia Construction Co., 17 E. 6th St., Cincinnati
Thomas Construction Co., Sandusky
Thurber & Browning Co., The, 4312 Spring Grove Ave., Cincinnati
Tressel, J. J., Ada
Trippeer & Patterson, Columbus
Turnbull Bros., Canton
Turner Construction Co., Youngstown
Ule, W. E., Ravenna
Urban & Clements, Massillon
Van Camp Bros., Newtonville
Vogelsburg, Theo., London
Walther, A. J., Wapakoneta
Warner, Kennedy, Medina
Warner-McKechnie Co., Toledo
Warner, Sam, Fort Recovery
Warrick, J. P., Cadiz
Watters, C. H., 53 E. Exchange St., Akron
Welling & Grans, 9th and Blum St., Cincinnati
Westrick, J. A., Holgate
Wieland, G. F., Mt. Gilead
Williams, H. L., Kenton
Wilson & Beckler, Lancaster
Wilson & Hampshire, Circleville
Wilson Engineering & Construction Co., Xenia
Wilson, Tibero & Robinson, Youngstown
Wilson-Yardley Co., Newark
Windsor Construction Co., Akron
Witham, C. S., Deshler
Wixom & Coghlin, Spitser Bldg., Toledo
Wolfe & Seiple, Second National Bk. Bldg., Toledo
Wright & Chessel, Kent
Wright, W. N., Lisbon
Zeller & Drum, Swanton
Zieg Mfg. Co., F. B., Fredericktown
Ziegler & Reardon, Fremont
Ziegler & Snyder, Piqua

Oklahoma

Gibson, Kelly F., Tulsa
Hoffman & Co., J. W., Muskogee
Inland Construction Co., Chandler
King, J. Berry, Tahlequah
Langtry, J. T., Tulsa
McCormick, F. P., Tulsa
McEachin Construction Co., McAlester
McNeal, J. W., Tulsa
National Paving Co., Oklahoma City
Nolan, John E., Sapulpa
Park-Morgan Co., Okmulgee
Rooks, John W., McAlester
Sandringham Co., Oklahoma City
Southwestern Gravel Co., Ardmore
Swatek Paving Co., Pawnee
Thompson, John, Ringling
Western Paving Co., Oklahoma City

Oregon

Arenz Construction Co., Salem
Coast Bridge Co., Portland
Cochran & Sons, T. H., Portland
Feldschan & Jackson, Tillamook
Garrett, J. H., Klamath Falls
Heinecke Bros. Co., Lumberman's Bldg., Portland
Hildeburn, H. J., Roseburg
Hinsdale & Jewett, Roseburg
Huber, Oskar, Portland
Kline, L. F., 1323 North West Bank Bldg., Portland
Longston & Co., Coquille
Longstrom & Co., W. A., Marshfield
Miller & Bauer, Portland
Montague-O'Reilly Co., McMinnville
Oregon Hassam Paving Co., Portland
Oregon independent Paving Co., Salmon St., Portland
Perham, E. G., Marshfield
Porter & Conley, Portland
Standard American Dredging Co., Astoria
Standefer-Clarkson Co., Portland
Warren Construction Co., Portland
Weekly, E. E., Roseburg
Western Paving Co., Astoria

Pennsylvania

Abrogast, E. P., Stroudsburg
Ambler-Davis C., 14 S. Broad St., Philadelphia
Applegate & Son, M., 6 Foreman St., Bradford
Austin & Matthews, Connellsville
Axe, George, New Wilmington
Bader, Harry J., Philadelphia
Baldwin, R. V., Coraopolis
Ball, James W., Wyncote
Bank Construction Co., J. Lennett Bldg., Wilkes-Barre
Barbutti, R. M., Dunmore
Barnitz, Geo. A., York
Barr, Peter, Shamokin
Battenfeld, J., 6 Sedgwick St., Millvale
Bell-Bockel Co., Altoona
Benedict, Hovey E., Williamsport
Bennett & Shearer, Indiana
Booth & Flinn, 1942 Forbes St., Pittsburgh
Borneman-Beitler Construction Co., Inc., 1317 Land Title Bldg., Philadelphia
Bruce Steel Co., Hollidaysburg
Bush & Stewart, Williamsport
Central Construction & Supply Co., Harrisburg
Challis, D. A., Sewickley
Coon Construction Co., B. G., Coatesville
Corcoran Construction Co., West Chester
Coryell Construction Co., Williamsport
Cronin Co., Thomas, 17th and Muriel St., Pittsburgh
Crossan Construction Co., Brownsville
Crosier, T. H., McKeesport
Cullen, Jas. B., Midland, Pa.
Cunningham & Sons Co., R. H., Turtle Creek
Cupani, Angela, Midland
Custer & Sons, Daniel, Johnstown
Davis & Perry, 19 Union St., Dorranceton, Wilkes-Barre
Davis, Wm. P., 413 Walnut St., West Chester
Detwiler & Bro., C. I., New Enterprise
Dick, J. I., Scottdale
Donora Construction Co., Donora
Doran, John F., 428 Marshall St., Morristown
Doyle, Wm. H., Berwyn
Dunleavy, C. H., Coatesville
Duster Contracting Co., Tarentum
Dwyer & Co., Philadelphia
Eastburn Co., Charles T., Yardley
Eastern Paving Co., S. 8th St. and Gray Ave., Philadelphia

Edwards, L. F., Greensburg
Elder, John L., Ebensburg
Ensign Inc., G. W., First National Bank Bldg., Harrisburg
Evans, W. C., Ambler
Field, Barker & Underwood, Philadelphia
Fiss & Christiano Shamokin
Flinn, Wm., 1455 N. Highland Avenue, Pittsburgh
Foley, T. J., Brownsville
Francis, J. D., Punxsutawney
Galloway, John L., Norwood
Gamble Co., Samuel, Carnegie
General Supply & Construction Co., York
Gillespie & Son, Oakview
Giorni, V. D., Fayette City
Grothe, William H., York
Haigh, Arthur H., Post Office Bldg., Germantown
Hamilton, C. F., Franklin
Harris, G. B., Meadville
Hartley, John W., York
Herrick Construction Co., Bennett Bldg., Wilkes-Barre
Hileman & Co., L. H., New Kensington
Hobelitz & Price, Meyersdale
Hoover, John T., Uniontown
Hunter & Co., R. D., Beaver
Hutchisen, J. M., Box No. 366, Altoona
Jones & Co., L. O., Duquesne
Juniata Co., The, Empire Bldg., Philadelphia
Keller, D. E., Somerset
Kelley, James E., Darby
Keystone Construction Co., Meadville
Love & Son, Elmer M., Corry
McCool Construction Co., Philadelphia
McClellan, William, Strafford
McCormick & Son, John, Erie
McCready Bros. Co., Pittsburgh
McGuire & Co., J. G., New Brighton
McIntyre & Sons, Wm., Sharon
McMullen, H., Banksville
McNerney Construction Co., Canton
McPherson Bros., Edgeworth
McQuison, R. C., Sharon
Mack Construction Co , 20th and Sedgley Ave., Philadelphia
Malloy, M. J., Sugar Notch
Mangan & Pugh, Pottsville
Manwaring & Cummings, Philadelphia
Mayer Bros. Construction Co., Erie
Meckes, F. P., Long Pond
Metz, L. V., Erie
Miller Construction Co., The, Lock Haven
Monongahela Construction Co., Inc., Pittsburgh
Monroe Paving Co., Betz Bldg., Philadelphia
Morrison, W. S., 330 Twelfth Avenue, New Brighton
Neff, Horn & Co., Slatington
Nelson, Merydith Co., Chambersburg
Nolan Bros., Reading
O'Brien Bros., Avoca
O'Connell & Son, D. E., Avondale
O'Connell, D. E., Kennett Square
Offutt, James H., Greensburg
O'Herron Co., M., Wilkinsburg
Ott & Co., Matthew, 414 Warren Ave., Pittsburgh
Parson Construction Co., Brownsville
Philadelphia Paving Co., 1345 Arch St., Philadelphia
Pittsburgh Amiesite Co., 310-11 Jenkins Arcade, Pittsburgh
Rae, Walter S., Oliver Bldg., Pittsburgh
Rees, C., 317 E. Noble St., Nanticoke
Regan & Lynch, Bute Rd., Uniontown
Ridge Bros. Co., Pittsburgh
Ring & Co., P. N., Mahanoy City
Ross & Watson, Oakmont
Scanlon, M. J., New Castle
Shand, Jr., A. C., Commercial Trust Bldg., Philadelphia
Sheehan, J. B., Bradford
Simpson, W. C., Punxsutawney
Snyder & Co., Paul J., Philadelphia
Souder Construction Co., Inc., Lancaster
South Shore Construction Co., Erie
Srucker Bros., Harrisburg
Steel, Bruce, Hollidaysburg
Stern, Jacob, Stroudsburg
Stewart, J. F., 55th and Walnut Sts., Philadelphia
Sweeney, John B., McKeesport
Taylor, Albert, Collingdale
Taylor, R. B., Bellefonte
Torquato Bros., Windber
Trexler, J. B., Reading
Union Paving Co., Philadelphia
Van, Edwin H., Betz Bldg., Philadelphia
Walter, Chas. P., 449 State St., Harrisburg
Weaver Construction Co., 1306 Gordon St., Allentown
Welland Co., J. E., Pittsburgh
Wickersham, B. F., Kennett Square
Wiesner, Jos., St. Marys
Wilt, Wm. W., 170 13th St., Franklin
York General Supply & Construction Co., York

Rhode Island

Bristow, John, Narragansett Pier
Callan, L. H., Tiverton
Callan, L. H., Bristol
Cullinan Co., Thos. F., 48 Custom House St., Providence
Dube, E. J., Warren
McCormick, Jos., E. Providence
McDonald & Son, Robert, Cumberland
Narragansett Improvement Co., 122 Public St., Providence
Narragansett Improvement Co., Olneyville
Price, Alfred, P. O. Box No. 552, Wakefield

South Carolina

Horton & Co., Anderson
Lawrence, J. D., Columbia
McCrady Co., W. S., Charleston
Steele, J. R., Bennettsville
Simons Mayrant Co., Charleston

South Dakota

Atkinson Paving Co., C. H., Watertown
Gage & Co., L. E., Sioux Falls
Siemback, G. A., Yankton
Smith, Dan, Mitchell

Tennessee

Ball & Peters, Memphis
Beard Construction Co., Morristown
Bennett & Maloney Construction Co., Chattanooga
Campbell & Son, John E., Humboldt
Carson & Co., Knoxville
Conner & Co., J. J., Knoxville
De Franceschi & Co., A., 751 Monroe Ave., Memphis

Ely Construction Co., Chattanooga
Freeman-Robbins Co., Knoxville
Gibson Construction Co., Knoxville
Gulf Paving Co., Chattanooga
Harvey & Co., F. D., Memphis
Hilliard, T. L., Jackson
Hood, Claude, Knoxville
Howard & Co., G. B., 150 Fourth Ave., North, Nashville
Maloney, Fred, Knoxville
Mann Construction Co., Knoxville
Memphis Asphalt & Paving Co., Memphis
Municipal Paving Co., Nashville
Muray Construction Co., Knoxville
Noll Construction Co., Chattanooga
O'Connor & Bro., John J., Knoxville
Oliver-Hill Construction Co., Knoxville
Pouncey Paving Co., Memphis
Riley-Ryan Co., Chattanooga
Roper Bros., Memphis
Southern Paving & Construction Co., Chattanooga
Thompson, Graham Co., Builders Exchange, Nashville
Wartrace-Fairfield Turnpike Co., Wartrace
West Construction Co., Chattanooga
Wilkes, R. A., Columbia
Wilkes, R. A., Culleoka
Williams, Boyd, McMinnville

Texas

Alamo Construction Co., San Antonio
Arnold, M. J., San Antonio
Bexar Construction Co., San Antonio
Brower, O. O., Houston
Burns, P. G., Houston
Callahan Construction Co., W. E., 1107 Busch Bldg., Dallas
Chambers Co., A. M., Houston
Cobb & Gregory, Houston
Chapin-Colglasier Cons. Co., 427 Moore Bldg., San Antonio
Cook, Richardson & Arrington, Center
Couch & Holliger, Houston
Cullom, Henry, Dallas
Dawson, A. H., Shepherd
Dawson, N. A., Newton
Dawson, N. A., San Antonio
Eads & McMahon, Lockhart
Eagle Lake Gravel Co., Houston
El Paso Bitulithic Co., El Paso
Eureka Construction Co., Port Arthur
Eureka Paving Co., Houston
Field & Co., Julian C., 105 Field Bldg., Denison
Finley Method Co., San Antonio
Finley Method Co., Houston
Frost, J. H., San Antonio
General Construction Co., Fort Worth
Good Roads Construction Co., Galveston
Gregory, Newman B., Box 126, Texarkana
Groos, Franz C., San Antonio
Hadden & Bates, Galveston
Haden, W. H., Galveston
Hamer, J. T., Seguin
Hess & Skinner, Dallas
Hoffman & Co., J. W., Denison
Howard, E., Thorndale
Irick & Penick, Olton
Levy, Lester, Houston
Lovett, T. F., San Juan
McClelland, V., Silsbee
McCollum, H. K., Forth Worth
McCoy, W. P., Arlington
McElreath, O. C., Gilmer
McMillan, F., San Marcos
Montgomery-Perkins & Co., San Antonio
Moor Construction Co., Lee, El Paso
Moore & Sons, J. S., Lufkin
Otto, M. C., Houston
Pearson & Co., M. L., Houston
Richardson & Arrington, Crockett
Roberts, I. H., Wichita Falls
Rushmore & Gowdy, San Antonio
Simms, R. L., Fort Lavaca
Sline, Layden & Davis, Terrell
Smith, A. J., Houston
Smith Bros., Crockett
Smith & Snowden, Cuero
Southern Paving Co., Dallas
Standard Engineering & Construction Co., Dallas
Standard Paving Co., San Antonio
Stegall & Jarett, Waxahachie
Taylor, Walker & Bell, Dallas
Texas Bitulithic Co., Dallas
Texas Grading Co., Houston
Tri-State Concrete Co., El Paso
Vibrolithic Construction Co., Terminal Bldg., Dallas
Warren, J. W., San Antonio
Western Paving Co., Amarillo
Western Paving Co., Dallas
Western Paving Co., San Antonio
Womack Construction Co., Van Alstyne

Utah

Gilkerson, H. G., Salt Lake City
Mellen, J. W., Salt Lake City
Moran, P. J., Salt Lake City
Nelson, O., Logan
O'Neil Construction Co., J. P., Ogden
Parrott Bros., Salt Lake City
Ryberg Bros., Kerns Bldg., Salt Lake City
Strange & McGuire, Salt Lake City
Wheelwright Construction Co., Ogden

Vermont

Moore, E. F., Burlington

Virginia

Addenbrook's Sons, J. U., Norfolk
Albert Bros., Shawsville
Atlantic Bitulithic Co., Richmond
Betts & Boyce, Harrisonburg
Betts, Fred H. Jr., McGaheysville
Billings, A. Q., Richmond
Black & Co., K. L., Richmond
Calvin & Gibson, Culpeper
Colbert, L. R., Massaponax
Cumberland Construction Co., Big Stone Gap
Curley, J. J., Richmond
Davis & Co., M. S., Clintwood
Emporia Concrete & Construction Co., North Emporia
Ford & Co., J. R., Lynchburg
Gannaway-Hudgins Co., Hampton
Greenleaf-Johnson Lumber Co., Norfolk
Henley, C. M., Richmond
Larner & Co., Wm., P. O. Box 512, Staunton
Lawson Construction Co., Norfolk
Lee Construction Co., S. E., Emporia
Luck Construction Co., Roanoke
McClay, A. W., Richmond
McGuire Construction Co., Norfolk
McGuire, F. J., Norfolk
Mitchell & Cochran Co., Chatham
Perkinson & Finn, Petersburg

Perkinson, J. L., Petersburg
Phillips' Sons, A. L., Richmond
Rowbie, A. B., Potomac
Tuggle, J. C., Bland
Vaughan Construction Co., Roanoke
Walton Construction Co., Falls Mills
Weinbrunn, C. M., Richmond
Williams, O. L., 215 South St., Portsmouth
Winston & Co., Richmond
Wolford, Phipps & Hibulin, Coeburn

Washington

Albers & Son, Geo. J., Chehalis
Allred & James, Centralia
Arp & McElroy, Edmonds
Ball, N. W., Seattle
Bandaret, G. A., Bellevue
Barbo Bros., Bellingham
Baumgartner, A. J., 711 16th St., Seattle
Baxter & Co., E. C., Maple Falls
Bernard, E. E., Richland
Bragg & Co., Bert, Colfax
Brown, O. S., Prosser
Burnett Construction Co., Seattle
Carlson & Chindahl Co., Spokane
Cascade Construction Co., North Yakima
Cascade Construction Co., Central Bldg., Seattle
Clifton, Applegate & Co., Spokane
Coluccio & Niblett, 1642 Lane St., Seattle
Coulter, K. L., Seaview
De Camp, R. B., 1503 Maxwell St., Spokane
Dunn & Co., P. G., Seattle
Erickson, Anderson & Hicks, Tacoma
Ferguson Construction Co., White Bldg., Seattle
Fiorito & Bros., M., Seattle
General Construction Co., Spokane
Goerig, L. H., 3611 E. Terrace St., Seattle
Graff & Sheldon, 1414 Tacoma Ave., Tacoma
Graves, G L. 728 Old Nebraska Bldg., Spokane
Grays Harbor Construction Co., Hoquiam
Green, H. C., Spokane
Hall, D. G., & Voulter, Daniel, South Bend
Hanson & Vatne, 105 N. 84th St., Seattle
Harkness & Co., P. D., Tonasket
Hastings, J. W., Spokane
Hendricks & Ward, Chehalis
Heskett, Frank H., Concrete
Holt & Jeffery, Transportation Bldg., Seattle
Hoover, W. J., Everett
Independent Paving Co., Seattle
Jacobs-Frank Taylor, New Kamilche
Jahn Contracting Co., The, Seattle
Johnson, Nels, Hoquiam
Kaiser Co., H. J., Everett
Kinder, S. G., Bridgeport
Lanning, L. L., Walla Walla
Lewis, C. H., Curlew
McEachern & Co., Seattle
McHugh, P. J., 3d Ave. N. and Mercer St., Seattle
Mohr Construction Co., Waterville
Moran Bros., Bellingham
Mulligan Co., W. G., 301 Eagle Bldg., Spokane
Northwestern Paving Co., E. 529 Erming Ave., Spokane
O'Dell, Mark, 707 Security Bldg., Seattle
Patton & Smith, Prosser
Payne, C. M., Spokane
Peterson, Torger, Eatonville
Picken, R. L., Tonasket
Quigg Construction Co., Wenatchee
Reinseth Bros., Everett
Ristved & Bragg, Colfax
Root, H. C., Spokane
Sawyer Bros., Spokane
Schaller, Clem, Okanogan
Schold & Co., A. E., Port Orchard
Silverton & Williams, 2823 S. J. St., Tacoma
Skagit Construction Co., Mt. Vernon
Sloan Bros., Seattle
Smith, J. L., 143 21st St., Seattle
Smith, J. T., Prosser
Smith, W. J., Ritsville
Sparger Concrete Co., Colman Bldg., Seattle
Spokane Asphalt & Macadam Paring Co., Spokane
Standard Asphalt Paving Co., Spokane
Stevenson, R. G., 1327 Ewing St., Seattle
Stickler, G. L., Colfax
Stickler, G. L., Davenport
Traphagan, D. H., Alaska Bldg., Seattle
Tribo & Grebling, Walla Walla
Voluccio & Niblett, 1642 Lane St., Seattle
Ward & Templeton, Everett
Washington Paving Co., Seattle
Western Paving Co., Empire Bldg., Seattle
Wilson, H. L., Walla Walla
Zindorf, M. P., Seattle

West Virginia

Adkins, M. L., Branchland
Allen, Wayne, F, Clarksburg
Baker, R. F., Bluefield
Ball Engineering Co., Wheeling
Balengee, S. C., Talcott
Brown & Floyd, Charleston
Brubaker Construction Co., Huntington
Cass & Meyers, Wheeling
Central Engineering Co., Charleston
Diddler, G. W., Philippi
Dougher, W. E., Sonceverte
Duval, Frank, West Huntington
Freshwater & Sons, E. A., Chester
Fuccy, J., Weston
Gillespie, L. J., Huntington
Harrison & Dean, Huntington
Hatfield Construction Co., Huntington
Henkle, Geo., Huntington
Henning & Hagerdorn, Pineville
Hornor Bros., 314 W. Main St., Clarksburg
Hottell Construction Co., Pulaski
Hudson Paving & Construction Co., Charleston
Hudson, R. M., Charleston
Keeley Bros., Pineville
Kennedy & Son, C., Parkersburg
McCormick Engineering Co., Morgantown
McFadden, R. J., Cameron
McGrath, J. K., Mt. Hope
Ollom, J., Huntington
Scanlon, T. S., Huntington
Shipe & Thompson, Huntington
Sisler & Morse, West Union
Smith, Harry F., Piedmont
Stender Construction Co., Huntington
Trainor, Amos, Huntington
Virgie, W. B., Clarksburg
Ward, Miller & McCoy, Wheeling
Weaver & Glover, Charleston
Williamson & Co., Grafton
Winston & Co., Pineville

Wisconsin

Badger Construction Co., 1015 Railway Exchange, Milwaukee
Birdsall-Griffith Construction Co., Racine

Brown & Connors, Janesville
Cape & Son Co., James, Racine
Cast Stone Construction Co., Eau Claire
Caughlin & Co., F. P., E. Sharon St., Milwaukee
Conlon, R. F., Cuba City
Coslin & Mogunson, Marinette
Cullinane, J. R., 618 W. Dayton St., Madison
Czerwinski, Geo., Milwaukee
Deam Construction Co., West Allis
Eul Construction Co., Fred, Menasha
Gaffin & Gehri, Fond Du Lac
Hildebrand, Jr., Fred, Milwaukee
Johnson, Chris, Oshkosh
Kelly, Edwin, Cazenovia
Kramp, A. J., Berlin
Kroening Construction Co., Majestic Bldg., Milwaukee
Kroening Construction Co., West Allis
La Crosse Stone Corpn., 28th and Main Sts., La Crosse
Larsen, A., Eau Claire
Larsen Construction Co., Oshkosh
M. & O. Construction Co., Madison
Manger Construction Co., Milwaukee
McGovern & Co., Wm. T., Milwaukee
Murphy Construction Co., Manitowoc
O'Neill, John S, 307 Pereles Bldg., Milwaukee
Peppard & Fulton, Superior
Pestien & Naumann, Sheboygan
Peterson Construction Co., The, Kenosha
Rasmussen & Sons, J., Oshkosh
Retslaff & Froemming, 1326 Humboldt, Milwaukee
Russell Construction Co., Superior
Stanfield, G. H., Fond du Lac
Sweeney Bros., Reedsburg
Weiher, John, 878 Franklin Place, Milwaukee
Welsch, W. J., Lancaster
Western Improvement Co., Racine
White Construction Co., Railway Exchange Bldg., Milwaukee
Wilcox, James, Foxboro
Wilcutts & Co., R. J., Foxboro
Wooley, T. E., La Crosse

APPENDIX

LEGISLATION DURING JANUARY-MARCH, 1917

Arizona

Instead of an annual appropriation of $250,000 a tax of 10 cents on $100 has been adopted. This is divided into 75 and 25 per cent funds, as before.

Arkansas

The legislature has created an advisory board of the State highway commission and appropriated $100,000 for the commission, and $496,134 for carrying on improvements. The board consists of the engineer and consulting engineer of the State highway department and a member appointed by the governor for a two-year term.

State roads are designated as "public roads which lead from one county seat in one county to another county seat in another county, or from one county seat in one county to another county seat in the same county, or from a county seat along highways leading into other States, or any other rural post roads within or without an improvement district, excluding every street or road within the corporate limits of any city of the first or second class."

The highway fund now receives all of the motor vehicle license fees, less 2.5 per cent for collection. Delinquent fines of $3, in addition to the regular fees, are divided equally between the State highway fund and the collector.

An improvement on which State or federal aid or both is desired originates with an application for such aid to the State highway commission by the county judge or the commissioners of a legally organized road district. The State highway engineer prepares plans, specifications and estimates of the improvement, which are submitted with the application to the advisory board. The advisory board, if it approves the application, recommends to the State highway commission the amount of aid to be granted and sends a copy of this recommendation to the local official making the application. Only projects of a "substantial character" may be approved, and the formalities in the case of federal aid must be observed to the satisfaction of the Secretary of Agriculture. When the State highway commission ascertains that all the steps to be taken under the State and federal laws have been properly taken, the local authorities are notified and the State treasurer is notified of the amount allotted from the State highway fund for the project. This amount must not exceed 50 per cent of the total estimated cost. The State highway commission is authorized to represent the local authorities in all negotiations relating to the use of federal aid funds.

No State or federal aid is given for a road until the county court sets aside the 3-mill road tax collected within a distance not exceeding 3 miles of the road, or so much of the tax as may be necessary, for the maintenance of the road to the satisfaction of the State highway department and the federal government, or makes some equally good provision for its maintenance. No State or federal aid is given to a road improvement district unless its commissioners levy a sufficient yearly tax to maintain properly the roads constructed by the district or the county court sets aside a sufficient amount for the purpose from the 3-mill tax.

The department of State lands, highways and improvements may pay the proportion of the aid granted by the State to any road district by labor of State convicts when they are not otherwise employed by the penitentiary authorities. Convicts so worked are under the care of wardens named by the penitentiary authorities, but the number to be worked and the manner of working them are determined by the State highway department.

Illinois

At the date of going to press a $60,000,000 State bond issue bill had fair prospects of passing the legislature; if passed it will be submitted to popular vote in November, 1918. About 16,000 miles of State-aid roads have been laid out and over 400 miles have been improved, but the work has been so scattered and disconnected as to be of only local value in many cases. The purpose of the bond issue is to build about 4000 miles of connecting roads in all counties, serving nearly all places of more than 2000 population and many of the smaller villages.

Indiana

A State highway commission of four members has been created. The members are appointed by the governor and serve four-year terms, except three of the first four appointed, who will serve one, two and three years respectively. The commissioners are to receive $600 a year each, and select a State highway engineer and fix his salary. He selects his assistants. The commission must hold at least one meeting each month and its total overhead expenses must not exceed $50,000 a year.

The commission is to designate certain roads as main market highways, their combined length not to exceed 2,000 miles by 1920. The contracts for the improvement of these roads are let by the county commissioners of the counties in which the roads lie, subject to the approval of the State highway engineer. If the engineer disapproves a proposed contract, the county commissioners may appeal from his decision to the State highway commission. If the commission sustains the engineer it may direct the county commissioners to advertise for new bids, or it may, if desired, advertise for bids and let the contract itself. The plans for the construction and maintenance of main market roads will be prepared by the State highway engineer and must be submitted to the county commissioners, and the plans must be drawn so the county commissioners can make a choice between at least two road materials.

Other roads than the main market highways may be constructed under the direction of the State highway engineer on the petition of 50 freeholders of any county, filed with the county commissioners. The entire cost of these roads is borne by the counties in which they are situated.

The funds for the work under the State highway commission comprise $100,000 for 1917 and $500,000 for 1918 from the general State fund, about $400,000 collected annually under the inheritance tax law, the federal aid allotments ranging from $407,242 during the year ending June 30, 1917, to five times that sum at the end of the fifth year, and at least 50 per cent of the cost of each improvement from the county in which it is made.

Kansas

A State highway commission has been created, consisting of the governor and two members appointed by him. The commission appoints a chief engineer and secretary. The commission has supervision over the construction and maintenance of all roads except township roads not receiving federal aid. It is authorized to devise a uniform system of road accounting which all local road authorities must employ. Competent engineers approved by the commission must be appointed by the counties, at salaries fixed in the law. The county engineers and county commissioners classify the roads as "county roads" and "township roads." The map of the county roads of a county must be approved by the State highway engineer and if a county fails to submit one for approval the State highway engineer may designate the county roads. All plans for improvements on the county roads must receive the approval of the State highway engineer; work under them is conducted by the county. A county road tax of 0.25 to 1.5 mills must be levied, and over 1.5 may be levied if the electors vote for it. Plans for township roads are made by the county engineer, whose approval is required for all expenditures exceeding $200 for construction and materials and $100 for machinery. The township road work must be done under a road overseer approved by the county engineer, and the latter determines the roads to be dragged. The tax for township roads is restricted to 3 mills unless a larger rate is voted by the electors. Incorporated cities do not pay this tax.

Michigan

At the time of going to press there were a number of road bills under discussion in the legislature.

One bill provided a method of allotting State and federal money on the basis of the assessed valuation per mile of trunk roads. Where this valuation is $100,000 or less, the local government unit pays 25 per cent of the cost of an improvement and the State and federal governments pay the remainder. For valuations of $100,000 to $200,000, the local unit pays 30 per cent; $200,000 to $300,000, 35 per cent; $300,000 to $400,000, 40 per cent; $400,000 to $500,000, 45 per cent; above $500,000, 50 per cent. Every local unit receiving such aid must raise annually for maintenance 3 per cent of the sum it contributed toward construction.

A second bill doubles the amount of the State reward for cement concrete, bituminous concrete and brick roads and increases the width of roads meriting rewards from 16 to 20 feet. Local authorities are compelled to maintain State reward roads adequately, and the State reward for maintenance is increased to 4 per cent of the total reward for construction, up to a maximum of $75 per mile.

A third bill prohibits the use of any vehicle loaded to produce a gross weight exceeding 600 pounds per inch width of tire, and the use of any vehicle except farm implements and road machinery weighing loaded over 15 tons. Maximum wheel loads and speeds of motor vehicles are made to depend on the size of the tire and the diameter of the wheel, and their maximum overall dimensions are fixed at 96 inches width and 12 feet 6 inches height. When the roads are soft in March, April and May, the maximum loads are limited to one-half of the amounts permissible at other times.

A fourth bill appropriates $1,300,000 for trunk line rewards and expenses for 1918 and 1919.

Missouri

The 1917 legislature created a State highway board of four members appointed by the governor for four-year terms, two from each of the leading political parties at the last presidential election. They are paid $1000 annually. The board appoints a State highway engineer, who must be a graduate of an engineering school with at least five years practical experience in road and bridge construction. He appoints two assistants; his salary is not to exceed $5,000 and that of his assistants not over $2,500 each.

The State highway engineer is to designate, subject to the approval of the board, at least 3,500 miles of road, divided among the counties in proportion to their area, population and road mileage, as State roads, and to increase this mileage when funds are available at the rate of at least 500 miles annually. They must have a right-of-way of at least 40 feet and must be selected "with due regard to directness and persistence of routes, low grades, economy in construction and maintenance, probable volume of transportation and general adaptation to the needs of the people of the State at large." These routes are to be surveyed by the State highway engineer, but the cost of the surveys must be borne by the counties or civil subdivisions in which the roads are located. The State highway engineer may accept maps offered without charge by county engineers or other persons.

If a county or a subdivision of it desires to improve a State road it must submit plans, specifications and estimates of the work to the State highway engineer in a form satisfactory to him. If he approves them, he includes the improvement in a project statement for federal aid and authorizes the local authorities to proceed with the construction. One-half of the cost is to be met from the State road fund and one-half by the county or its civil subdivision. Project statements for federal aid are to be prepared with a view to distributing fairly among the counties the available federal funds.

The State road fund comprises motor vehicle license fees, corporation license fees, all contributions from federal funds and all general or special State taxes and fees for road purposes. This fund is used for the expenses of the State highway department, the construction of federal aid roads, dragging inter-county seat highways, and to assist counties, townships and districts. The State and the counties contribute equally to the cost of State roads. All roads constructed with aid from the State road fund must be maintained by the counties in which they are located to the satisfaction of the State highway engineer; no further state assistance will be rendered in case the maintenance is unsatisfactory. No State aid is granted to a county which does not raise the maximum legal road taxes or issue road bonds equalling 3 per cent of its assessed valuation.

All poles, pipes, railways and other structures on the right-of-way of State roads are under the control of the State highway engineer and must be placed and maintained in agreement with the regulations of the State highway department.

The members of the commission are E. L. Sanford, chairman, C. O. Raine, George E. McInnich and A. C. McKibbin, secretary.

Montana

A law has been passed reorganizing the State highway commission and placing 12 members on the board.

The automobile license fees have been fixed at $5 for cars up to 23 horse power, $10 for those between 23 and 50 horse power, and $15 for those exceeding 50 horse power; motor trucks, $5 for 1-ton, $15 for 2-ton, $25 for 3-ton and $40 for all over 3-ton; chauffeurs, $2; dealers, $50; motorcycle dealers, $15. One half of this money is repaid to the counties whence it came and half is placed to the credit of the State highway commission. It is estimated that the fees will amount to about $250,000.

The members of the commission are: Oscar Rohn, Butte; Charles Buford, Virginia City; Frank Conley, Deer Lodge; A. W. Morrison, Ft. Benton; Sam Webb, Columbus; D. T. Curran, Missoula; A. W. Mahon, Glasgow; F. H. Johnson, Kalispell; T. F. Hagen, Glendive; Hugh Wells, Miles City; A. E. Richardson, Forsyth; H. A. Templeton, Great Falls.

Nebraska

The 1917 legislature appropriated $200,000 for State aid to counties in building bridges over 175 feet in length, the counties to match the State funds. At the time of going to press, a bill appropriating $640,000 seemed likely to pass.

New Jersey

A State highway commission has been established, consisting of the governor and eight members appointed by him, two of whom must be engineers. They serve four years and receive no salary, but are paid their expenses. The commission appoints a State highway engineer for five years at a salary fixed by it, and also an assistant State highway engineer. All other appointments are to be made from the civil service lists. The commission takes over the work previously done by the State commissioner of public roads and the State highway commission. In addition it has control of the construction and maintenance of State highways and may carry on work by contract or day labor. The State road fund at the disposal of the commission comprises the legislative appropriations, motor vehicle license fees, fines, federal aid money and State road taxes. An amount equal to the State road tax must be spent for the extension and construction of State highways. The remainder is available for department expenses, acquiring toll roads and bridges, and aid to counties and municipalities in constructing and maintaining roads and bridges.

The commission is required to lay out 15 State highways along routes indicated in the law. The existing pavements on roads taken to form parts of these routes may be maintained by the commission but all new pavements must be "granite, asphalt or wood blocks, brick, concrete, bituminous concrete, sheet asphalt or other pavement having a hard surface and of a durable character." The width of these pavements must be 18 feet at least and the total width of the roadway at least 30 feet. All construction and maintenance of State highways is under the charge of the State highway commission. No structures of any sort are permitted on the right-of-way without the consent of the State highway commission. No State highway may extend into any municipality, other than a township, having a population exceeding 12,000, but the State highway commission may contract with local authorities in such exempted places to maintain certain streets and roads in a condition in keeping with the State highways entering and leaving them. Local boards and individuals may contribute funds toward the cost of any State road work.

A 1-mill tax on each dollar of assessed valuation of real and personal property must be levied annually for five years for the State road fund.

The office of State engineer was created, to advise with the State highway department, commissions having to do with interstate tunnels, harbor and port commissions, and the governor. Gen. Geo. W. Goethals is State engineer and Robert A. Meeker is State highway engineer.

John W. Herbert, Anthony R. Kuser, George W. F. Gaunt, Col. E. A. Stevens, W. G. Clark, W. J. Buzby, Ira F. Kip, Jr., and George A. Blakeslee have been appointed commissioners.

New Mexico

A State highway commission has been created, consisting of three members appointed by the Governor for six-year terms, one every two years. The commission appoints a State highway engineer and fixes his salary, and may designate the State engineer as the State highway engineer, in which case the salary of the State engineer will be increased $1000. The employes of the commission are appointed by the State highway engineer, who is its executive officer. Under the direction of the commission he designates a system of state roads "which shall, as nearly as practicable, be such as will best serve the traffic needs and develop the resources of the State." He is required to determine the best methods of road construction and maintenance for different parts of the State and may be consulted by local road officials regarding highways and bridges. County officials must furnish him with information regarding their roads and bridges, and are subject to a fine of $10 to $100 if they fail to do so.

Improvements on State roads originate with an application by the county commissioners for such an improvement. If the application is approved and county and State funds are available for the work, the State highway engineer prepares the plans and specifications and lets the work by contract if it costs over $1000. If the cost is less than that amount the county may be permitted to do the work. The county must furnish the right-of-way. Not more than 50 per cent of the cost is paid by the State. In case the county does not apply for an improvement the commission may carry it out at the cost of the State. Roads built partly with State and partly with county funds must be maintained by similar joint contributions under the direction of the State highway engineer.

Funds are provided by a 1-mill tax and one-half the net motor vehicle license fees. At least 20 per cent of the total sum must be spent on maintenance, and enough of the balance must be reserved to equal the federal aid funds granted to the State and the expenses of the department. Seventy-five per cent of the balance must be spent in the counties in proportion to their assessed valuation, excluding cities and towns with over 2000 population. Taxes may be anticipated by issuing certificates bearing not over 5 per cent interest and running not more than 2 years.

Counties are credited with the value of work done on State roads by county convicts, and the value of work by State convicts is credited to the State.

Other roads than State roads are under the county commissioners. The work is done in each county by a county highway superintendent employed by the State highway commission, which fixes his salary, although he is paid by and works under the general direction of the county commission. His accounts and records must be kept in a form prescribed by the State highway engineer and by a system prescribed by the State highway commission.

The State engineer, James A. French, has been appointed as State highway engineer.

North Carolina

The method of carrying on road improvements has been materially changed as a result of the enactment in March, 1917, of what is called the "State wide county road law."

Upon receipt of a petition by 100 freeholders of any county, its board of county commissioners must order an election on issuing bonds for road improvements, provided the petition states the mileage to be improved, the amount of the bond issue, the State highway commission has informed the county commissioners that the issue will be adequate to carry out the improvements proposed, and the issue will not raise the entire bonded debt of the county above 10 per cent of its assessed valuation. Upon receipt of a petition from 100 freeholders of a county, its board of county commissioners must order an election on levying a road tax, provided the petition states the mileage to be improved by the tax, the length of time it is to be levied, and the amount, which must not exceed 50 cents on $100 of assessed valuation and $1.50 poll tax, and provided the board has been informed by the State highway commission that the proposed tax will furnish sufficient funds for the improvement. In case a county does not vote for bonds or a special road tax, any township in a county may act. Upon petition of 25 freeholders, the county commissioners must hold an election on an issue of bonds or the levy of a special road tax by the county commissioners for the township under the same conditions governing a county bond issue or special tax, except that the provisions apply only to the township. Where township road bonds have been issued the law provides for retiring them by issuing county bonds, if the voters elect to do so. Road districts are given the same opportunities as townships.

Upon petition of 100 freeholders, the board of county commissioners must order an election on the creation of a county road commission of three members, one of whom must be a member of the minority political party. The term of office of a member of the commission is six years. In case the petition for a county bond issue or special tax does not state that the work under the issue shall be done by an existing commission, a county road commission must be appointed to carry it out. The commission is appointed by the board of county road commissioners, and practically has charge of all roads in the county. If a county road commission has been appointed to carry on the work in a township or road district, this commission has charge of the work undertaken later by other townships and districts by bond issues or special road taxes, if the freeholders so desire. The commission may employ an engineer, but this is not obligatory.

If it is stated in the petition for a bond issue or special tax that the proceeds shall be distributed in proportion to the taxes of the different townships, this will be done, but otherwise the commission in charge of the work expends the money as it considers for the best interests of the road work of the county as a whole.

Whenever the road conditions in a county, township or district are such that the available money is insufficient for the completion of necessary work in the judgment of the commission in charge of it, this commission may apply to the board of county commissioners for emergency assistance, which is to be furnished by the board out of the general funds of the county or by issuing short-terms notes or bonds to an amount not exceeding in any year one per cent of the taxable valuation of the county, township or road district.

Whenever road bonds are issued or a special road tax is levied, an additional special maintenance tax must be levied sufficient to raise 1 to 4 per cent of the par value of the bonds or of the proceeds of the special road tax to be used in maintaining the roads built with these funds.

The necessary land for right-of-way may be taken when needed. If the owner and the commission cannot agree upon a fair price for any parcel so occupied, the commission is directed to appoint, after the road has been built, three disinterested freeholders to assess the damages and benefits upon the property resulting from the construction of the road. If the benefits exceed the damages the excess amount is assessed on the land. The commission has the right to obtain timber and road materials on any land in the county, to extend the road drainage system upon abutting property, to cut down trees for a distance of 30 feet on each side of the road if necessary for its maintenance, and to acquire a right-of-way of not less than 40 feet for all roads.

Where a road traverses two counties but follows approximately the boundary line between the two, either county which desires to improve the road may do so, even that part in the adjoining county. When completed each county is to maintain its portion. A county is also authorized to build a section of road in an adjoining county when it is necessary to connect its roads with those of the adjoining county.

When convicts are sentenced to road work the expense of maintaining and guarding them is paid out of the general funds of the county, while the road commission pays for their quarters and has supervision of their care, food and clothing. Permission is given to work trustworthy convicts without guards or distinctive clothing, and to commute their sentences from 25 to 50 per cent for satisfactory work and good behavior.

In counties where able-bodied men must work a certain number of days on the roads, this labor can be commuted at the rate of 75 cents per day. The men can be called upon to work for a period of three consecutive days at any time in the year until their full period of service has been exhausted. Anyone subject to such work who fails to perform it or commute the service is guilty of a misdemeanor punishable upon conviction by a fine of $5 to $25 or imprisonment for 5 to 10 days.

Road districts can be created by majority vote of the free-holders of the proposed districts or by the county road commission on petition of the owners of 60 per cent of the property in the districts. The districts created in the latter manner are called special road districts and consist of the land running back half a mile from each side of the road to be improved. The rate of assessment in a special road district is based on the distance of the land from the road; the district bears two-thirds of the cost and the county one-third.

The net proceeds of the automobile license fees are paid into a separate highway maintenance fund spent by the State highway commission for the maintenance of the State system of highways. Seven-tenths of the money must be spent within a year of the time it is collected in the counties from which the fees were derived.

Only railway companies are permitted to erect on or near a highway a sign containing words imitating railway signs. Guide posts must be placed at intersections and forks by the commission in charge of the roads at such places.

North Dakota

A State highway commission has been created in North Dakota, consisting of the governor, State engineer, commissioner of agriculture and labor, and two members to be appointed by the governor. The State engineer is the chief engineer and secretary of the commission and is paid $1000 a year in addition to his salary as State engineer.

The State engineer is required to prepare a map of the highways of the State and a map of those main highways which in the judgment of the several boards of county commissioners and the highway commission are of sufficient importance to be designated as State roads. The system of State roads may be amended from time to time by the State engineer, subject to the approval of the State highway engineer.

The preliminary work of the commission will be done under an appropriation for the purpose, forming the nucleus of a State highway fund. The remainder of the fund will be furnished by two-thirds of the net proceeds of the automobile license fees. These fees are collected by the secretary of State, who pays one-third of the net proceeds to the counties for use in repairing and dragging roads solely.

The county commissioners of a county which desires State aid in improving a State road must apply to the State highway commission for it. If the application is approved the State engineer prepares the plans and specifications for the work and if the cost exceeds $3000 he advertises it and lets the contract. If the cost is less than $3000 he may do the work by day labor or let it by contract or allow the county to carry it out. Half of the cost is paid by the State and half by the county, and the law requires the road thereafter to be maintained under the supervision of the State engineer at the joint expense of the State and county.

The license fees for motor vehicles are $6 for those of 20 horse power or less and 50 cents for each additional horse power during the first three years of its registration in the State and half these amounts for each succeeding year. Motorcycle registration is $3.

A tax must be levied in townships having graded roads sufficient to raise $5 per mile of road, to be spent in dragging the roads.

Ohio

A large number of changes were made early in 1917 in the road laws. A highway advisory board of four members, not more than two from any political party, has been created to pass upon the recommendations of the State highway commissioner regarding matters of general policy, particularly those of changes in main market and inter-county roads and the relations of the State with the federal government.

The basis of allotting the State highway improvement fund has been changed to permit greater coöperation between the State and the less wealthy counties; counties with an assessed valuation under $20,000,000 now pay 12 per cent of the cost of an improvement, townships 8 per cent, property owners 5 per cent and the State 75 per cent. Where the assessed valuation is from $20,000,000 to $30,000,000 the State pays 60 per cent, the county, 20 per cent, the townships 12 per cent and the property owners 8 per cent. Elsewhere the former rates of 50, 25, 15 and 10 per cent are retained in force.

Townships now have authority to improve roads under practically the same conditions as counties, and the laws relating to county road building have been simplified and enlarged in some details. Township trustees are authorized to issue bonds for road purposes without a popular vote. Township trustees may form road districts without including municipalities lying within their boundaries where the tax rate is too high to permit an additional levy. The road work in these districts is conducted as in the townships. The dragging of unimproved roads is compulsory and the first appropriation from township funds must be for such work.

Appropriations for the year ending June 30, 1918, comprise $155,960 for the maintenance of the State highway department, $1,544,000 to police, patrol and maintain highways; $562,000 to construct, improve, maintain and repair main market roads; $1,546,540 to construct, improve, maintain and repair inter-county highways; total, $3,808,500.

Appropriations for the year ending June 30, 1919, comprise $155,960 for the maintenance of the State highway department, $2,210,000 to patrol, police and maintain highways; $562,000 to construct, improve, maintain and repair main market roads; $1,580,000 to construct, improve, maintain and repair inter-county highways; total, $4,507,960.

Oregon

Under a new law a State highway commission of three members is appointed by the governor. The governor has appointed S. Benson, Portland; W. L. Thompson, Pendleton; and E. J. Adams, Eugene. The commission serves without pay, but the members receive their expenses. The commission selects a State highway engineer and will have charge of the work done with the proceeds of a $6,000,000 bond issue, if that issue is approved at a special election on June 4. The commission designates the State highways, and improvements on them must be made from the plans and under the supervision of the State highway engineer.

The State highway commission must set aside first from the highway funds of each year a sum sufficient to meet the federal aid for the State, and if the highway funds are inadequate for the purpose State bonds must be issued for the balance needed.

Registration fees for automobiles have been fixed at $3 for motor cycles, $6 for electric pleasure vehicles, $10 for electric service vehicles, $6 for steam and gasoline vehicles up to 26 horse power, $10 for vehicles of 26 to 36 horse power, $15 for those of 36 to 40 horse power and $20 for those of more than 40 horse power. Motor truck fees range from $15 for vehicles under 2 tons to $30 for those of 4 to 5 tons. No vehicle of over 5 tons capacity can be operated on a public highway except on a special permit from the county court, designating the routes of operation and the term of the permit. The county court must collect at least $8 a month for such a permit and in addition a $5 registration fee must be paid to the State. The net proceeds of these fees are credited to the funds controlled by the State highway commission.

A tax of 0.25 mill must be levied annually, the proceeds to be paid into the State highway fund. After the federal aid and administrative expenses are provided for, the balance may be used in coöperative improvements and maintenance of the State highways, with the counties.

Philippine Islands

Important changes in the form of government of the Philippine Islands were made through the passage of the Jones Bill by congress in August, 1916. The entire legislative power is now vested in a bicameral legislature, with few exceptions the members of which are elected by popular vote. The Governor-General is the executive and administrative head of the government, and has a qualified veto upon the acts of the legislature. The secretary of commerce and communications has general charge of roads throughout the islands. Design, construction and maintenance of all roads and bridges are in the hands of the bureau of public works, except for city streets and a few unimportant *barrio* roads and trails. The field work of the bureau is distributed through 43 districts, each under a district engineer. Four of the district engineers have supervisory jurisdiction over the districts contiguous to their own, but all report directly to the director of public works at Manila. Thirty-five per cent of the number are Filipinos. There is also a highway engineer in general charge of highway design and specifications.

Progress.—At the close of 1916 there were approximately 3450 kilometers of first-class road in the islands, all with heavy surfacing and approved cross-section, gradient and alignment; 3000 kilometers of lightly surfaced or earth second-class roads, and 5650 kilometers of ungraded third-class roads and trails. All of these are under continuous maintenance, the first-class roads by the isolated *caminero* (patrol) system, the others by maintenance gangs, the maintenance in each district being in direct charge of one or more Filipino foremen reporting to the district engineer.

Most of the surfacing is of the waterbound type, with broken stone, river gravel and beach coral as the principal materials employed, and this type has proved for the most part, by moderate maintenance costs, that it is well suited to the traffic using the roads. There are a few provinces, however, notably Leyte and Albay, where the development of heavy automobile truck traffic during the last two years has been very great and with diastrous results to the roads. Standards of construction are being changed to meet these conditions, and stringent automobile legislation has been enacted by the legislature for the regulation of motor traffic, especially as to character and width of tires and as to speed, in relation to the loads carried. Some 20 kilometers of first-class road have been surfaced with bituminous macadam, and several short stretches with Portland cement concrete, the latter not so much on account of heavy traffic as for the purpose of protecting the road-bed from being scoured out by the heavy floods that pass over it during every rainy season.

In developing the different provincial road systems a great through highway extending the entire length of Luzon Island, a distance of 1360 kilometers (845 miles), has never been lost sight of. This road has been financed largely, at least in its interprovincial sections, by insular funds, and is now open as a continuous road from Hondagua, an important Pacific port, through Manila to Bangui at the north end of the Island, a distance of 838 kilometers (521 miles). It is all first-class but 205 kilometers, of which 150 kilometers are second-class and so passable the year round. The road now passes through Baguio, the principal health resort of the Philippines, by a detour which includes the Benguet and Naguilian Roads with their 67 kilometers of mountain scenery, but a coast road is under construction to connect the lowland termini of these two roads and thus shorten the through road by 36 kilometers. For the last two years the Benguet Road has been maintained almost entirely from the proceeds of toll collections, and the costs have been kept to moderate proportions by sending most of the heavy truck traffic, upon which the City of Baguio has to depend for supplies of all kinds, over the Naguilian Road. The latter had 52,000 pesos spent on it during 1916, half of which went for resurfacing those sections which were opened to traffic with light surfacing only, and for the removal of slides.

Road funds.—No road funds in the Philippines have so far been raised by bond issues, due principally to the comparatively low first cost of the roads and to the preponderance of local over insular value in them. At present, however, the advisability of building certain roads of concrete, brick, etc., to meet the demands of heavy truck traffic, is being discussed, and also the value of the first-class road as a development factor for unsettled areas, so that bond issues in the near future are not improbable.

Construction expenditures for 1916 have run fully as high as those for 1915, given on page 171, and the maintenance bill for the year is considerably higher, being estimated at 1,700,000 pesos, for first-class roads only, or 528 pesos per kilometer ($425 per mile).

The licensing of motor vehicles is in the hands of the bureau of public works, and also the operation of the Benguet Auto Line, which operates over the Benguet and Naguilian Roads. The revenues from both these sources are generally allotted to special maintenance projects.

The highway officials at the beginning of 1917 were: E. J. Westerhouse, director of public works; D. E. Henry, chief constructing engineer; C. E. Gordon, chief designing engineer; R. H. Doane, consulting architect; A. D. Williams, J. L. Harrison, Claud Russell, R. V. Glenn, and F. T. James, supervising engineers; W. C. West, highway engineer.

South Carolina

A State highway commission has been created consisting of the senior professors of civil engineering at the University of South Carolina, Clemson Agricultural College, and the Military College of South Carolina, and two members appointed for two years by the governor. They serve without pay but receive their expenses. They appoint a State highway engineer, who appoints not more than two assistant engineers. The commission must coöperate with the local road authorities and ascertain the best methods of road construction and maintenance for the different sections of the State. The State highway engineer must furnish advice, plans and specifications to the local road authorities and, in some cases, supervise construction. Funds for the commission are provided by an automobile license fee of 25 cents per horse power and dealers' license fees of $15, payable to the State highway engineer and forming a State highway fund. One-fifth of this fund is available for the State highway commission and four-fifths must be returned to the counties where the money is collected and be placed to the credit of the counties' road funds.

Applications for federal aid are made by the counties to the State highway commission, which transmits those approved by it to the federal authorities. The law provides that the counties must give all the guarantees required by the federal aid road law before the applications are transmitted to the federal authorities, and that the applications of the counties may be supplemented by projects prepared by the State highway commission, if it deems best. The commission is authorized to pledge the good faith of the State for the payment of any balance needed to meet the federal aid funds and not furnished by the counties.

The chairman of the commission is J. Monroe Johnson, of Marion, one of the two members appointed by the governor, the other being C. O. Hearon, of Spartanburg. The designated members are Prof. M. Goode Homes, of the University of South Carolina, Prof. Haile Houston, of Clemson Agricultural College, and Major R. G. Thomas, of the Military College of South Carolina.

South Dakota

A State highway department consisting of the governor, State engineer and a member appointed by the governor, has been created. It supervises, controls and directs the building of public roads and bridges on which State or federal aid is spent. Eighty per cent of all State road funds must be spent in the counties where collected, if the counties apply for such distribution, and both State and federal aid are to be distributed as nearly as practicable on the basis of the population, assessed valuation and road mileage in each county. The department designates roads of general importance to the State as State highways, authorizes their improvement, and pays for the work "out of any funds that may be appropriated for State road building," but the counties contribute a part of the cost.

Homer M. Derr is State engineer; his office is at Pierre. The commission will not be organized until July 1, 1917, at which time the new law becomes effective.

Texas

The legislature has passed a bill establishing a State highway commission of five members. The commission will select the State highway engineer and fix his salary. He prepares plans and specifications for the work done by State and federal aid and supervises its execution. The State highway commission is authorized to make all necessary contracts with the United States Department of Agriculture to receive federal coöperation.

A State highway fund has been established out of 50 per cent of the net proceeds of the annual automobile license fee of 35 cents per horse power. The other 50 per cent is to be paid by the State highway commission, which is charged with collecting the fees, to the counties where it originates.

The State highway commission is to designate the State highways and to select the roads to be submitted to the United States Secretary of Agriculture for approval as federal aid roads. Any county receiving State aid for the improvement of the State roads within its boundaries must contribute either 50 or 75 per cent of their total cost, according to the assessed valuation of the county.

County commissioners desiring to issue bonds for highway improvements may call upon the State highway commission for advice concerning the feasibility of doing the proposed work with the money which it is anticipated will be derived from the sale of the bonds.

Utah

A State bond issue of $2,000,000 has been authorized, the proceeds to be spent for roads and bridges by the State road commission. The motor vehicle license funds are used in paying interest and principal. The State road commission consists of the governor, State engineer, attorney general, secretary of state, and State auditor.

Washington

Under the 1917 legislation, the primary State roads are maintained by the counties under the supervision of the State. In addition to other funds, a specific allowance of $100 per mile annually is made from State revenue for the maintenance of primary highways. Five per cent of the permanent highway fund is set aside for maintenance of the roads improved with a 1.5-mill tax, augmented by the net proceeds of motor vehicle license fees. These fees are expected to yield $500,000 in 1917 and $750,000 in 1918.

The 1917 legislature appropriated $1,812,052 for State roads during the two years ending March 31, 1919, and reappropriated $127,249 for that purpose. It also appropriated $3,942,018 and reappropriated $1,050,180 for permanent highways. It is estimated that $6,000,000 of county funds will be spent on roads during the two years. The federal aid road law will furnish $700,000 during the fiscal years 1917 to 1919.

West Virginia

A State road commission of two members, one from each of the two political parties casting the largest votes at the last general election, has been created. They are appointed by the governor and hold office for four years. One must be a civil engineer with at least three years experience in highway work, and the other a man of "known and successful business qualifications." The commission may engage such assistants as it needs, within the limits of the appropriations for its work. The commissioners receive $3500 and expenses.

All public roads outside incorporated cities and towns are divided into two classes. Class A includes main county roads receiving federal or State aid, and Class B comprises all other roads, designated as district roads. The State road commission supervises the improvement of Class A roads, gives instruction to local road officials, is responsible for the enforcement of all road laws and aids the county officials in the improvement and maintenance of roads. No materials can be used in Class A roads without its approval, and it is authorized to test materials for county authorities. All road work and road financing by county officials are subject to its inspection.

The main county roads are selected by the State road commission and county courts jointly. The money for improving and maintaining these roads is raised by a county tax not exceeding 25 cents per $100 of assessed valuation. This money is expended under the direction of the county courts except when State or federal aid is given, in which case the State road commission has charge. In case of serious damage by floods, a special levy of 10 cents per $100 may be made with the approval of the State tax commissioner and State road commission. General plans and specifications for the improvement of main county roads are made by the State road commission, which has no authority over Class B roads except by special agreement with the county courts.

The State road fund comprises the net proceeds of motor vehicle license fees, legislative appropriations and federal aid. After deducting the commission's expenses the balance is distributed among the counties in proportion to their main county roads, but no county receives any of the fund unless it contributes an equal amount.

One or more magisterial districts or a county may issue bonds or authorise a special road tax for not more than ten years by a three-fifths vote, held after the cost of the work has been estimated by an engineer and the proposition has been approved by the State road commission.

District road funds may be raised by tax levies not exceeding 15 cents per $100 of assessed valuation, and special levies of 10 cents are permitted for emergency work. The labor tax of one to four days work annually may be commuted at the rate of $2 per day.

Where there is a county road engineer he is also the road supervisor, but a road supervisor not an engineer may be appointed in counties not employing engineers. The county road engineer or supervisor coöperates with the State road commission and represents the county in work on Class A roads, and acts as the agent of the county court in all other road work. He purchases all materials and machinery with the court's approval. The roads in a county may be divided into sections not exceeding 2 miles in length for maintenance by contract or by day labor, or the patrol system may be adopted.

Road work on which State convicts are used must be carried out in accordance with plans and specifications prepared by the State road commission, which is authorized to operate quarries and brick plants by convict labor to supply materials to the counties. The guards, quarters, clothing, food and transportation of convicts on road work are provided by the warden of the penitentiary but the work is directed by the State road commission. The convicts must not be worked over 10 hours a day and are to be paid for time over 9 hours at the contract rate paid by the county to the State. If the work is done by contract, the State may furnish convict labor at the rate of $1 per day per convict to the amount of the State's contribution toward the cost of the improvement.

Vehicles wider than 90 inches are permitted only on wide roads and require a special permit even then. No vehicle weighing over 15 tons or having a gross loaded weight exceeding 600 pounds per inch width of tire can be operated on the roads, except by special permission and then only on heavy travel roads. The annual license fee for motorcycles is $5 and for other motor vehicles $10 plus 25 cents for each 100 pounds weight exceeding 2000 pounds. All motor vehicles operating as omnibuses or delivery wagons for public or private service outside incorporated cities and towns must pay for special permits at rates fixed by the State road commission.

Wyoming

The 1917 legislature created a State highway commission of five members, serving six years and appointed by the governor, not more than three to be from the same political party. They represent five geographical districts named in the law and receive a salary of $600 and their traveling expenses. The commission appoints a State highway engineer and fixes his salary. He has charge of laying out highways upon which State funds are spent, the purchase of machinery and equipment, and the employment of assistants, subject to the approval of the commission. A tax of 0.25 mill on each dollar of assessed valuation is levied for 1917 and 1918 for a State highway fund, in which will also be placed all other money received from any source for expenditure by the commission.

The highways to receive State and federal aid are designated by the commission in conjunction with the boards of county commissioners, but before any road is so designated the county commissioners must appropriate half of the cost of the improvement. All work done with State funds is performed in accordance with plans and specifications prepared by the State highway engineer and under his direction. The State highway engineer must also furnish to any board of county commissioners upon request plans and specifications for highway improvements. All bridges costing over $200 or more than 5 feet in span must be built to his satisfaction from his plans. All roads built with State aid are designated as State roads and must be maintained to the satisfaction of the State highway engineer by the counties in which they lie. The State highway commission may prescribe methods of accounting for road construction by the counties and regulations governing the issue by the State highway engineer of certificates of competency for persons employed by the counties as superintendents and foremen.

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